Towards an Engineering Process for Developing Accessible Software in Small Software Enterprises

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Abstract: This study presents the results of a web accessibility evaluation performed on a sample of six software products developed by small software enterprises of two countries. According to the International Standard Organization (ISO), an enterprise, organization, department or project with up to 25 people is considered small. All the products evaluated presented accessibility issues, mainly lack of HTML labels, alternative texts, and color contrast errors. These results showed there is a need in small software enterprises of an engineering development process that, taking into account their constraints of staff and budget, includes activities for improving the accessibility of their software. We present the current state of an ongoing work to define such process based on ISO/IEC 29110 that includes accessibility-related task in each of the following activities: initiation, analysis, design, construction, integration and test, and delivery.

1 INTRODUCTION

The European Commission (EU, 2015) defines two factors to define the size of a company: staff headcount and annual turnover. A company with less than 10 employees and less than 2 million annual turnover is a micro enterprise; a company with less than 50 employees and less than 10 million annual turnover is a small enterprise, and a company with less than 250 employees and less than 50 million annual turnover is a medium-sized enterprise. Micro, small and medium-sized enterprises (SMEs) represent 90% of all businesses in the European Union. Laporte et al. (2015) reports that in the United States, micro enterprises with less than 10 employees account for 57% of companies. Moreno-Campos et al. (2014) presents statistics for the Information Technology (IT) sector. In Europe, 85% of the IT companies have less than 10 employees. In Montreal, Canada, 80% of the IT companies have less than 25 employees. In Wallace, Belgium, 60% of the IT companies have less than five employees. In Northern, Ireland, 66% of the IT companies have less than 20 employees. Sanchez-Gordon (2012) reports that 90% of the Ecuadorian IT companies have less than 10 employees.

ISO (2011a) defines a very small entity (VSE) as an enterprise, organization, department or project with up to 25 people. VSEs that develop software face many challenges to embrace traditional software engineering processes, let alone to include additional tasks to improve the accessibility of the software they produce.

In this study, we present the results of accessibility evaluations performed to software products developed by six VSEs. These results point to the need of software engineering approaches with accessibility considerations specifically designed for VSEs.

This proposal is based on the standard ISO/IEC 29110 "Software Engineering -- Lifecycle profiles for Very Small Entities (VSEs)" (ISO, 2011b). This standard has two processes: Project Management and Software Implementation. The Project Management process carries out the tasks of the software project to achieve the objectives with the expected quality, time and cost. The Software Implementation process is the systematic execution of initiation, analysis, design, construction, integration and test, and delivery activities for developing or maintaining software products, as show in Figure 1 (Laporte et al., 2015).

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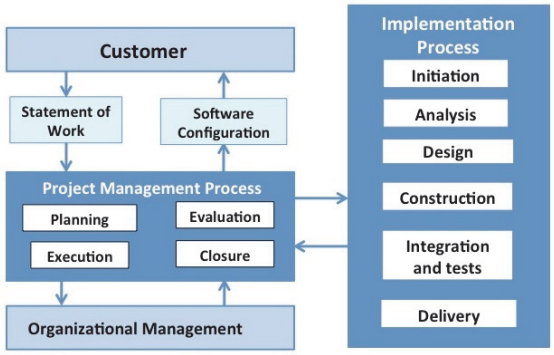

Figure 1: ISO/IEC 29110 processes (Laporte et al., 2015).

In the literature review, we found some published research about ISO/IEC 29110, including a systematic review of 24 studies (Moreno-Campos et al., 2014; Sanchez-Gordon et al., 2015). There is one study about developing a social network website using ISO/IEC 29110 (Laporte et al., 2014). However, these studies do not considered accessibility. Conversely, we found few published research focused on accessibility in software engineering (Goncalves de Branco et al., 2014). Nevertheless, none of them applied to the specific context of VSEs.

The goal of the present study is to introduce a proposal for a software process for VSEs based on the ISO/IEC 29110 that includes accessibility-related tasks.

The rest of this paper is organized as follows: Section 2 explains the research method; Section 3 presents the results; Section 4 discusses the proposed engineering approach; and Section 5 presents final remarks and future work.

2 METHOD

The following steps describe the method used in this study. We selected the type of software product to be evaluated and defined the evaluation dataset consisting of a sample of six VSEs that have developed this type of software product. Then, we selected a tool to perform the accessibility evaluation of the software products in the dataset. Based on the analysis of the results and taking in account the constrains for VSEs, we proposed a software engineering process based on ISO/IEC 29110 that includes accessibility-related tasks.

2.1 Software Product

In Ecuador, companies must issue sales invoices electronically and these invoices must be available for future reference through web portals (IRS, 2014). Software companies have developed and deployed web portals for electronic invoicing for Ecuadorian customers. This is the type of software product evaluated in this study. The two user interfaces of interest are the Authentication web page and the Invoices Viewing web page.

2.2 Evaluation Dataset

We selected a sample of six web portals for electronic invoicing developed by five Ecuadorian VSEs and one VSE from Spain. Table 1 shows the VSE names and software product URLs.

Table 1: Accessibility evaluation dataset.

#	VSE Name	Software Product URL
1	Tandicorp	http://www.puntonatural.com.ec/
2	Under Media	https://www.flacso.edu.ec/swinfo
3	GPF	https://www.corporaciongpf.com/facturacionGPF
4	ANFAC	https://facturas.com.ec
5	Boyaca IT	http://facturacion.boyaca.com/
6	Zabyca	http://72.52.152.44/entrepapeles/

2.3 Evaluation Tool

We performed the evaluation using the web accessibility evaluation tool WAVE, developed by WebAIM. Specifically, we used the WAVE Chrome extension 1.0 released on November 2015 (WebAIM, 2015) and installed it on a Google Chrome Browser Version 47.0.2526.106 running on Windows 8.

3 RESULTS

In this section, we present the accessibility issues found in the software products evaluated, as well as the most common accessibility errors and alerts.

Figure 2 presents the evaluation results for the Authentication web page developed by VSE #5. WAVE presents the evaluated page with embedded icons. For example, red icons indicate errors and yellow icons indicate alerts. The other icons indicate accessibility features presented in the pages, structural elements errors, HTML5/ARIA errors, and contrast errors.

Table 2 summarizes the results of the Authentication web pages. The less accessible web page was developed by VSE #1 with 14 errors and 12 alerts, while the most accessible web page was

developed by VSE #2 with two errors and two alerts.

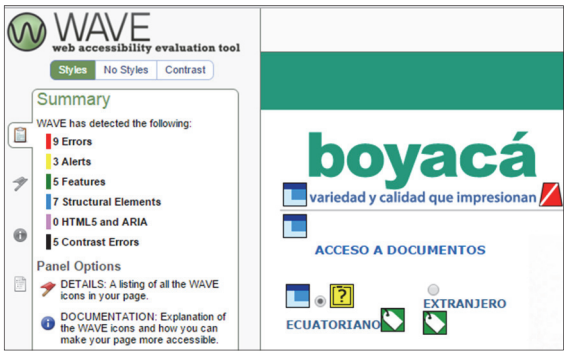

Figure 2: Results of VSE #5 authentication web page.

Table 2: Results of authentication web pages.

Issue Type	#1	#2	#3	#4	#5	#6
Errors	14	2	6	2	9	3
Alerts	12	2	3	7	3	5
Features	29	8	0	7	5	1
Structural	52	6	1	5	7	2
Contrast	2	2	2	6	5	2
ARIA	0	3	0	4	0	1

Similarly, Table 3 summarizes the results of the evaluation of the six Invoices Viewing web pages. In this case, the less accessible web page was also developed by VSE #1 with 43 errors and 128 alerts, while the most accessible web page was developed by VSE #6 with three errors and one alert.

Table 3: Results for invoices viewing web pages.

Issue Type	#1	#2	#3	#4	#5	#6
Errors	43	26	7	14	12	3
Alerts	128	89	124	4	2	1
Features	135	2	9	11	0	0
Structural	228	28	29	39	11	5
Contrast	6	4	11	0	12	1
ARIA	8	25	0	117	0	0

Figure 3 shows the five most common accessibility errors found in the web pages evaluated. The most common error was “Missing form labels”, with 77 occurrences that accounts for 54% of the errors. When a form control or input field does not have a properly associated text label, the function or purpose may be clear enough from the context when the content is rendered visually, but the label still needs to be provided to support other forms of presentation and interaction, such as for screen reader and speech input users. This corresponds to Web Content Accessibility Guideline (WCAG) 2.0 1.1.1 Level A, Controls and Input: “If non-text content is a control or accepts user input, then it has a name that describes its purpose” (W3C, 2008).

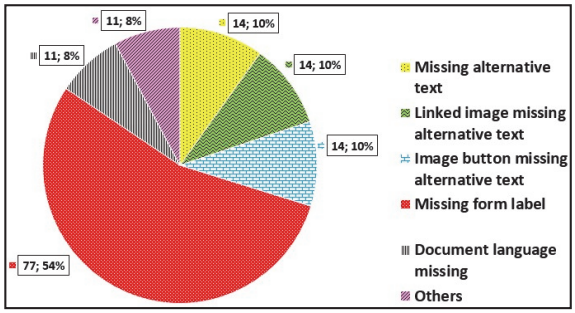

Figure 3: Five most common accessibility errors.

Figure 4 shows the five most common accessibility alerts found in the web pages evaluated. The most common alert was “Device dependent event handler”, with 258 occurrences that accounts for 68% of the alerts.

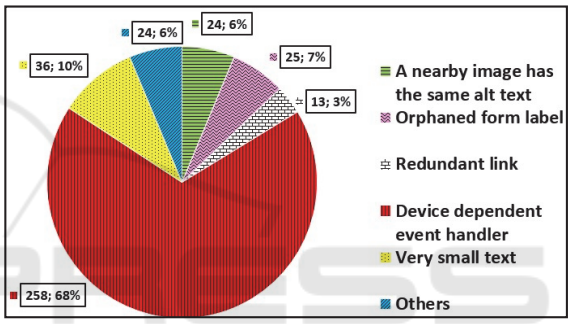

Figure 4: Five most common accessibility alerts.

Finally, the VSE #5 Invoices Viewing web page was the page with the highest number of color contrast errors: twelve. The color contrast between background and foreground colors was 3.6:1, which is low compared with the minimum of 4.5:1 recommended by WCAG 2.0 1.4.3 Level AA (W3C, 2008). This type of accessibility error has a huge negative impact in users with low vision.

4 DISCUSSION

In this section, we present the current state of an ongoing effort to define a software engineering process for VSEs that includes accessibility-related tasks. For each activity of the ISO/IEC 29110 software implementation process as explained by Gonzalez and Hernandez (2012), we present main constraints faced by VSEs and a preliminary list of tasks to improve the accessibility of the software products developed. For now, these lists are not exhaustive and once completed, they will serve as input for a comprehensive method.

The goal of the software implementation process is to achieve a software product that satisfies the needs and expectations of all potential users, including users with accessibility needs due to permanent, temporal, or environmental disabilities, e.g. users born blind, users with temporary immobilized arm due to surgery, or users working under extreme light conditions.

4.1 Software Implementation Initiation

This activity prepares the team for the rest of activities and it selects the tools to accomplish the project. Table 4 shows the tasks and roles.

Table 4: Initiation tasks.

ID	Task Name	Roles
SI.1.1	Review the project plan to achieve a common understanding and commitment.	Manager Team
SI.1.2	Set or update the implementation environment.	Team

In this stage, the main constraint for VSEs is limited budget for setting up the environment. The proposed accessibility-related tasks are (Keates and Looms, 2014):

- Select simulations aids for testing purposes, e.g. blindfolds, ear defenders.
- Select simulators for different types of disabilities, e.g. SimDaltonism simulates eight types of colour blindness (Fortin, 2014).
- Select assistive technologies, e.g. NVDA screen reader (Nvacess, 2015).
- Select accessibility evaluation tools, e.g. WAVE (WAVE, 2015).
- Select HTML and CSS checkers, e.g. W3C HTML Validator (W3C, 2013).

4.2 Software Analysis

This activity studies users' needs and expectations to define the project scope and identify key functionalities, including non-functional requirements. Table 5 shows the tasks and roles.

In this stage, the main constraints for VSEs are cost and time. Recruiting users with disabilities is costly. Moreover, it is unfeasible to include all types of potential users with disabilities. Including an accessibility expert is also costly. A participatory approach with users with disabilities and experts also demands time.

Table 5: Analysis tasks.

ID	Task Name	Roles
SI.2.1	Assign tasks to the team according to their role and the plan.	Manager Team
SI.2.2	Create or update the Requirements Specification. Identify information sources. Determinate the scope and feasibility. Verify the correctness and testability.	Team Customer
SI.2.3	Validate and obtain approval of the Requirements Specification. Validate the Requirements Specification traceability with the needs and expectations.	Customer

The proposed accessibility-related tasks are:

- Sensitize the team members through the observation of users with disabilities interacting with software products.
- Use a cost-effective and quick approach to gather and validate accessibility requirements based on guidelines and standards, e.g. WCAG 2.0 (W3C, 2008), ISO/IEC 13066 (ISO, 2011c).
- Include accessibility requirements in the Requirements Specification.
- When using agile development, include accessibility requirements in the product stack.

4.3 Software Design

This activity is the keystone of a software project. Failure to describe a design architecture that will incorporate all the requirements is a common reason for project failure. Table 6 shows the tasks and roles.

In this stage, the main constraint for VSEs is the size of the development team. The proposed accessibility-related tasks are:

- Review the design architecture, software components and interfaces for traceability with accessibility requirements in the Requirements Specification.
- Guide team members in getting accessibility knowledge and using techniques for building accessible software components, e.g. use of WAI ARIA in HTML5 (W3C, 2015).

Table 6: Design tasks.

ID	Task Name	Roles
SI.3.1	Assign tasks to the team according to their role and the plan.	Manager Team
SI.3.2	Understand Requirements Specification.	Team
SI.3.3	Create or update the Software Component Identification. Analyze the Requirements Specification to generate the components. Provide details of the software components and their interfaces.	Team

4.4 Software Construction

This activity involves programmers producing components using a systematic approach. Table 7 shows the tasks and roles.

Table 7: Construction tasks.

ID	Task Name	Roles
SI.4.1	Assign tasks to the team according to their role and the plan.	Manager Team
SI.4.2	Understand the Software Component Identification.	Team
SI.4.3	Construct or update the Software Components.	Team
SI.4.4	Create or update Test Cases and Test Procedures for unit and integration. Customer provides testing data.	Team
SI.4.5	Test the Software Components. Correct the defects found until successful unit test is achieved.	Team

In this stage, the main constraint for VSEs is the size of the development team and the short time to deliver. The proposed accessibility-related tasks are:

- Built accessibility features in the Software Components.
- Create Test Cases and Test Procedures for testing the accessibility requirements.
- Use accessibility checklists, e.g. WebAIM´s WCAG 2.0 Checklist (WebAIM, 2014).

4.5 Software Integration and Tests

This activity involves executing different types of tests and identifying issues that must be addressed. Table 8 shows the tasks and roles.

Table 8: Integration and tests tasks.

ID	Task Name	Roles
SI.5.1	Assign tasks to the team according to their role and the plan.	Manager Team
SI.5.2	Understand the Test Cases and Test Procedures. Set or update the testing environment.	Team
SI.5.3	Integrate the software using Software Components and update Test Cases and Test Procedures for integration testing, as needed.	Team
SI.5.4	Perform software tests using Test Cases and Test Procedures for integration and create the Test Report.	Team
SI.5.5	Correct the defects found until successful test is achieved.	Team
SI.5.6	Incorporate the Requirements Specification and Software to the Software Configuration.	Team

In this stage, the main constraint for VSEs is the size of the development team. The proposed accessibility-related tasks are:

- Use automated tools in the testing environment.
- When using agile development, include accessibility testing in the Definition of Done.

4.6 Software Product Delivery

This activity ensures there would be no delays to obtain product acceptance. Table 9 shows the tasks and roles.

Table 9: Delivery tasks.

ID	Task Name	Roles
SI.6.1	Assign tasks to the team according to their role and the plan.	Manager Team
SI.6.2	Review the Software Configuration for understandability.	Team
SI.6.3	Perform delivery to the Manager and support.	Manager Team

At this stage, the main constraint for VSEs is short time to deliver. The proposed accessibility-related task is to include the accessibility assets in the Software Configuration.

5 CONCLUSIONS

Building accessible software is the right thing to do because it benefits all users – both able and disabled. Besides, web accessibility is a legal requirement in several countries, the United States being the first country to have legislation on web accessibility since 1998. There have been more than 230 related settlements and lawsuits.

In the evaluation presented in this study, we found that all the software products in the sample have accessibility issues. The most common accessibility errors were missing form labels, missing alternative texts in linked images and image buttons, and document language missing. The most common accessibility alerts were device dependent error handlers and very small text. These errors and alerts prevent certain users from fully interacting with the software web pages.

In our proposal, for each activity of the ISO/IEC 29110 software implementation process, we identified constraints faced by VSEs and presented preliminary lists of accessibility-related tasks. We are working on improving these accessibility-related lists since they are not exhaustive.

As future work, we plan to systematize these lists to obtain a comprehensive method that can be applied for VSEs that develop software to improve the accessibility of their products. This method will have to be empirically validated in pilot software projects.

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