An Approach to Improve the Accessibility and Usability of Existing Web System

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ABSTRACT
The Web is currently the main way of providing computing services, reaching a larger number of users with different characteristics. As the complexity and interactivity of systems is increased, users become more demanding towards all the requirements associated to their distinct needs. Implementing the interaction requirements in the Web has become the main focus of accessibility and usability studies, describing essential design features which provide users with quality, assured systems. The focus on the users reinforced that as the number of users grows and the system became available to a wide variety of users, accessibility and usability features become even more critical to a Web application’s success. In this paper, we present ACCESSA, a practical approach to rapidly improve the accessibility of existing Web systems, acting mainly in the interface design with no changes to the functional requirements of systems. The ACCESSA is based on the WCAG 2.0 guidelines and other patterns, choosing the guidelines that present lower implementation costs and represent higher severity accessibility issues.

Categories and Subject Descriptors
H.5.2 User Interfaces [User-centered design]

General Terms
Design, Human Factors, Standardization, Languages.

Keywords
Web systems, Web Usability and Accessibility, User requirements.

1. INTRODUCTION
The continuous changing of the use perspective of the Web applications is an irreversible fact. Contents that were simple to navigate are becoming more and more complex due to updates of many dynamic components included in those systems [17]. One of the perceived reasons for these changes is the concern of the adequacy of the contents to the characteristics, diversity and needs of users, and the way they interact with information and services available on the Web [16].

With the technological advances and increased popularity of the Web, several technologies have been developed to extend the possibilities of HTML. However most of the companies and developers that create Web systems do not follow the standards that ensure the universality of the Web, such as: matching the possibilities of use, flexibility in use, simple and intuitive use, capture of information, fault tolerance, small physical effort, size and space to use interaction patterns [10]. This breaking with the standards and principles to create Web systems brought several consequences to their evolution, since the use of the Web by users with little experience and even for use on mobile devices is hampered by the lack of standardization [11].

Thus, even with advanced technology to promote various forms of Web interactivity, researches on digital inclusion for people with disabilities have shown not only the lack of accessible solutions in universities, business and government environment, but also the lack of usability in Web systems, since the interface is the communication part mainly for the user perform their tasks [11][13].

This paper presents an approach, named ACCESSA, focused on users to improve the accessibility and usability of existing Web systems. A viability study was realized for the evolution of the process and the users and specialist were essential to have a product that met all the requirements of users. We used the AgendAloca system (a Group Calendar system that aims to fill the gap between information for use by students and teachers at a specific University) as a viability study to perceive how user participation is fundamental to insert the attributes of accessibility and usability into Web applications, validating the Approach presented here. The development of two versions of AgendAloca system will be described, showing the evolution of the interface.

The main goal of ACCESSA is to use the triangulation of methods, which some designers already perform, focusing on their real results based on case study. Consequently, the approach proposed in this paper is practicable and may be useful for reengineering processes. Additionally, this paper presents some attractive ideas by combining the various aspects of usability and accessibility evaluation in one approach to rapidly improve the accessibility of a Web system, acting mainly in interface design without changing the functionality. This paper is organized as follows: in Section 2 the Accessibility and Usability of Web System is presented; Section 3 presents the proposal Approach. The Viability Study and AgendAloca System can be found in Sections 4. In Section 5 the results of the applied approach are presented, followed the results that compare two versions of the AgendAloca System in Section 6. Finally, in Section 7, final remarks are presented.
2. ACCESSIBILITY AND USABILITY OF WEB SYSTEM

A concept that is misunderstood in relation to accessibility is that to developing systems thinking about accessibility implies limitations in usability. Many developers argue that accessibility guidelines limit the use of technologies such as JavaScript, animations, applets and other technologies that can be used to improve the usability of a system. The recommendations do not preclude the use of these technologies, but only indicate that they should be used following certain principles and guidelines so that they do not become barriers [1][21].

Accessibility means unlimited use of Web systems for all people, independent of individual disabilities [11][25] and should be inserted early in the development process of systems, whether conventional or Web-based [18]. Despite the limitations of the Web Content Accessibility Guidelines (WCAG), such as the difficulty to understand the language that describes the guidelines [3], they are the dominant approach to support developers building accessible systems [11].

Although accessibility is an essential quality attribute for people with disabilities, it has not gained due recognition as a fundamental non-functional requirement in a software project, such as security, performance, accuracy and usability [1][14]. Even though most of the systems available do not show good accessibility [11], some studies have been concerned about how to incorporate accessibility in existing systems [19] to meet the needs of a diverse population and support the awareness of how the fact of considering accessibility helps developers building more usable systems for all people [34].

The current version of WCAG (2.0) was elaborated to be technologically neutral, being applicable to technologies available now and in the future. The guidelines also provide objective testable criteria that can be evaluated with a combination of automatic testing and human evaluation [35].

Many authors [8][15][22][32][33][35] argue that accessibility evaluation processes of Web interfaces, restricted to revisions with automatic accessibility evaluation tools, are sufficient. However, one of the problems with evaluations based only on automatic accessibility verification is that not all checkpoints can be automatically verified [31]. Another problem, mentioned by Brajnik [5], is that guidelines such as the WCAG do not enable the evaluator to distinguish serious problems from trivial ones, regardless of the existence of well-defined priority levels.

For instance, in the guideline checkpoint 1.1, in WCAG 1.0, it is recommended that every image that is presented on a Web page must have an alternative text, being a priority 1 checkpoint. However, according to Brajnik [5], most Web images have an “emotional” purpose, and do not aggregate content to the document. Thus, there is no need to effectively include an alternative text for every image. It is important to highlight that people with sensorial and/or cognitive limitations develop specific abilities, such as the preference for, and the use of keyboard key combinations, not usual to people who has not the referred limitations. Thus, Web accessibility evaluation should include, apart from automatic verification tools, user tasks verifications focused on difficulties encountered in performing daily work. These tasks can guide user’s mental models to overcome the difficulties, and contribute to making satisfactory the interaction of impaired users with a Web-based application of their interest.

Therefore, many authors have performed tests with the participation of real users to check the Web accessibility [22][26], since those tests simulate conditions of use from the final user’s perspective, by prioritizing, for instance, the analysis of the navigation easiness between screens of the user interface, and clarity of their texts and messages. This way, difficulties and problems faced by users during use sessions can be identified, enabling evaluators to formulate a more realistic diagnostic evaluation, and propose better corrective measures to designers. Based in these references, we created ACCESSA that can be used to improve the accessibility with some WCAG 2.0 guidelines.

3. THE PROPOSAL APPROACH

We present ACCESSA that is an approach focused on users to improve the accessibility of a Web System. The main idea is to rapidly improve the accessibility of existing Web systems, introducing practices to be included in interface the design phase of the development process, with no changes to the functionalities of systems. ACCESSA approach is based on the implementation of selected WCAG 2.0 guidelines and other patterns, which consist of accessibility features that present lower implementation costs and represent higher severity accessibility issues.

Figure 1 shows an overview of the ACCESSA approach, which makes use of four evaluation perspectives:

- T1) Inspection’s perspective is a conformance evaluation [5] given by an expert to determine if a Web site meets accessibility standards in accordance with WCAG 2.0 principles, which are Perceivable, Operable, Understandable and Robust;
- T2) Tools’ perspective is given by accessibility automatic evaluation tools, because the guidelines provide objective testable criteria, that can be evaluated with a combination of automatic testing (using automatic evaluation tools, like Hera and daSilva);
- T3) Expert’s perspective is given by people with sensorial and/or cognitive limitations develop specific abilities, such as the preference for, and the use of keyboard key combinations, not usual to people who has not the referred limitations. Thus, Web accessibility evaluation should include, apart from automatic verification tools, user tasks verifications focused on difficulties encountered in performing daily work. These tasks can guide user’s mental models to overcome the difficulties, and contribute to making satisfactory the interaction of impaired users with a Web-based application of their interest.
- T4) User’s perspective is given by the participation of real users to check the Web accessibility [22][26], since those tests simulate conditions of use from the final user’s perspective, by prioritizing, for instance, the analysis of the navigation easiness between screens of the user interface, and clarity of their texts and messages.

Therefore, many authors have performed tests with the participation of real users to check the Web accessibility [22][26], since those tests simulate conditions of use from the final user’s perspective, by prioritizing, for instance, the analysis of the navigation easiness between screens of the user interface, and clarity of their texts and messages. This way, difficulties and problems faced by users during use sessions can be identified, enabling evaluators to formulate a more realistic diagnostic evaluation, and propose better corrective measures to designers. Based in these references, we created ACCESSA that can be used to improve the accessibility with some WCAG 2.0 guidelines.

Figure 1. Overview of the ACCESSA

1. http://www.w3.org/TR/WCAG/
T3) **User’s perspective**, expressed by the user’s view of the interactivity of the system. It is represented by the retrieval of satisfaction data via three methods: 1) Pre-Section questionnaires (to collect the user profile) and Post-Section questionnaires (to collect user’s opinion about the Web system under evaluation); 2) informal think aloud method [23] (which lead subjects into saying out loud what they are thinking about when navigating in Web system) and 3) interview (to know the opinion of the users on the system).

T4) **Expert’s perspective**, provided by the analysis of the user performance during the execution of tasks [20][23], generating a set of change requirements.

In order to validate ACCESSA, we developed a viability study using the AgendAloca System, showing that rapidly achieves good improvement of accessibility in an existing system.

### 4. VIABILITY STUDY

According to Shull [29], the first study that should be made to evaluate a new approach is a viability study, which aims to verify whether this new technology is feasible and if the time spent is well used. These studies are typically performed in the academy, since they allow that new technologies be tested before being transferred to the industry to use them on a day-by-day basis.

#### 4.1 AgendAloca System

Group Calendar Systems (GCS) consist of systems that integrate information for personal use or for use in a particular group. GCS are calendars that can be shared on a network like the Internet, for example. These systems allow concurrent user interactions, which enhances user awareness of commitment schedules made by others and might impact in their planned activities [26].

In the University of São Paulo (USP), the presentation of final year undergraduate projects (Trabalho de Conclusão de Curso - TCC - in Portuguese) is an essential step towards any student graduation, in which students present their work to a panel of lecturers. GCS present an important role of reconciling the multiple presentations of works of all students in the university. The need for providing communication between students and lecturers to retrieve information related to the works that were developed (TCC) and dates that are convenient and available to both groups, were the main motivations behind the implementation of the AgendAloca system.

Before the development of the AgendAloca first version, the management of the schedule for presentations of the TCCs was performed manually; each student was asked to inform their preferred time and date for the presentation of TCC within a predetermined time. Thus, the version 1 of the online system on the Web was developed to manage the schedule and was used primarily to advertise the scheduled presentations online. It has been used for nearly six years by those involved (students and lectures). However, this initial version of the system was in disuse for no longer meeting the new requirements that came with new demands, such as the need of a feature that allow the participation of students and teachers while interacting in the choice of working hours through the system.

Over time the interaction with the system was intensified as the number of new users who had to access the system increased. Thus, accessibility and usability requirements became even more evident and had to be re-prioritized, and this led the development of AgendAloca version 2.

The AgendAloca version 1 was developed with CMS (Content Management Systems) Drupal version 6. The CMS Drupal was chosen due to the potential to reuse existing features and also for being an extensible modular framework, which allows adding features by means of the integration of modules (Figure 2).

![Figure 2. AgendAloca – version 1](http://agua.intermidia.icmc.usp.br/agendamento)

### Table 1. Summary of AgendAloca versions

<table>
<thead>
<tr>
<th>AgendAloca versions</th>
<th>Technologies used</th>
<th>Main requirements were met</th>
</tr>
</thead>
</table>
| Version 1\(^4\) (v.1) | CMS Drupal | - Manage the hours available for students to present TCC  
- Manage the participation of teachers in presentations scheduled by students |
| Version 2\(^5\) (v.2) | API JSF  
API JAX-rs  
API JAXB | - Manage the hours available for students to present TCC  
- Manage the participation of teachers in presentations scheduled by students  
- Insert accessibility and usability |

\(^4\) [http://agua.intermidia.icmc.usp.br/agendamento](http://agua.intermidia.icmc.usp.br/agendamento)

\(^5\) [http://garapa.intermidia.icmc.usp.br:3000/agendaloca](http://garapa.intermidia.icmc.usp.br:3000/agendaloca)
To develop version 2, it was necessary to conduct a viability study that is explained in the next subsections.

4.2 Planning
The viability study\(^7\) was conducted to evaluate the accessibility and usability of the AgendAloca System. The main hypothesis of this paper is to verify if the implementation of features associated to accessibility requirements also contribute to improve the general usability of the system.

In order to test our hypothesis we used ACCESSA (Section 3), to improve the accessibility of the AgendAloca system. And, then, we compared accessibility and usability metrics of the previous version of the system (v1) and the new generated version (v2). If the accessibility and usability metrics are both increased from the previous to the newer version of the system, then our hypothesis is supported by the viability study. If the accessibility and usability present different tendency in the metrics, then our hypothesis is rejected by the study.

As accessibility evaluation criteria, one quantitative metric was considered; the number of guidelines that did not have their Success Criteria met, according to a WCAG conformance evaluation.

As usability evaluation criteria, two quantitative metric groups were defined: the primary group consists of the metrics of time taken to perform a set of proposed tasks and the amount of errors obtained during an interaction session. The secondary group consists of metrics of amount of tasks completed successfully and the number of clicks performed during each task.

It is worth noticing that the ACCESSA approach includes four evaluation phases. And two of these phases have the objective of monitoring of the user’s activities using the Morae\(^8\) tool.

The participants, we tracked the usability evaluation criteria described in Section 5.1. The metrics were collected by means of real-time monitoring of the user’s activities using the Morae\(^8\) tool, as presented in Figure 3.

The viability study was conducted to verify our hypothesis validity.

4.3 Using the Approach
The ACCESSA was defined in order to raise the accessibility issues of the system and identify possible design solutions for these issues. In this context, we tested the first version of AgendAloca system with the four perspectives: the inspection’s perspective; the industrial’s perspective; the user’s perspective and the expert’s perspective.

4.3.1 Inspection’s perspective
The Inspection’s perspective consists of a WCAG 2.0 conformance evaluation to the system. The result was reported on a percentage scale of how many success criteria were not designed in the system for each WCAG 2.0 guideline. The results were generated by an accessibility specialist and are presented in Table 2.

AgendAloca v.1 does not support a great number of accessibility features. This is justifiable since the goal of the development was to deliver new functionalities with no understanding or knowledge about the accessibility guidelines. The few accessibility features that can be perceived are the result of CMS native modules, which were already implemented considering accessibility requirements. For instance, the mandatory use of alternative text on images.

Table 2. Evaluation of AgendAloca v.1 under inspection’s perspective

<table>
<thead>
<tr>
<th>Principles</th>
<th>Guidelines</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceivable</td>
<td>1.1 Text alternatives</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>1.2 Time-based Media(^6)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1.3 Adaptable</td>
<td>63%</td>
</tr>
<tr>
<td></td>
<td>1.4 Distinguishable</td>
<td>72%</td>
</tr>
<tr>
<td>Operable</td>
<td>2.1 Keyboard Accessible</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>2.2 Enough Time</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>2.3 Seizures</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>2.4 Navigable</td>
<td>38%</td>
</tr>
<tr>
<td>Final Average - Perceivable:</td>
<td></td>
<td>78.5%</td>
</tr>
<tr>
<td>Understandable</td>
<td>3.1 Readable</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>3.2 Predictable</td>
<td>92%</td>
</tr>
<tr>
<td></td>
<td>3.3 Input Assistance</td>
<td>53%</td>
</tr>
<tr>
<td>Final Average - Understandable:</td>
<td></td>
<td>55.6%</td>
</tr>
<tr>
<td>Robust</td>
<td>4.1 Compatible</td>
<td>45%</td>
</tr>
<tr>
<td>Final Average - Robust:</td>
<td></td>
<td>45%</td>
</tr>
</tbody>
</table>

4.3.2 Tools’ perspective
As Accessibility Evaluation and Repair tools in the Tools’ perspective evaluation phase, we used daSilva tool and aDesigner tool\(^30\). The daSilva tool reported the system presented 16 errors and that 11 errors were classified as priority 1, 4 errors were classified as priority 2 and 1 error, priority 3. daSilva also reported 116 warning messages, which indicate checkpoints (considering that the Accessibility Evaluation and Report tools used in the study classify the accessibility issues identified according to the WCAG 1.0) that need to be evaluated manually and could be harmful to the navigation of the website. We also tested the AgendAloca version 1 with the aDesigner tool to verify the accessibility of Web systems for blind users using colors and gradation. A single problem on the menu of the website was reported by the tool.

4.3.3 User’s perspective
The User’s perspective evaluation scenario was conducted with two students from the University of São Paulo. This target audience was recruited for convenience according to the main motivation of the developed Web system, which is to support students at the end of their graduation courses to schedule and organize end-of-course monographs and presentations.

The students were asked to complete a number of tasks on the AgendAloca system. While these tasks were realized by the participants, we tracked the usability evaluation criteria described in Section 5.1. The metrics were collected by means of real-time monitoring of the user’s activities using the Morae\(^8\) tool, as presented in Figure 3.

The tasks that the participants were asked to execute were:

1. To do log in;
2. To show their own data;
3. To see the Group Calendar;
4. To register two accounts of students and
5. To do log off.

Guideline 1.2 received 0 because the AgendAloca system does not use audio/video contents anywhere.

\(^6\) To realize this study an approval of the ethics committee was obtained. CAAE 05700912.5.0000.5390.

\(^7\) http://www.techsmith.com/morae.html
Both users are male and are 18 and 19 years old. They do not present any deficiency and present an Internet user profile of browsing the Web more than 24 hours per week in desktop, notebook and cell phone. They said that they like to learn new things and do not have fear or insecurity using the Web, but are not comfortable navigating through menus and going back to previous actions.

Some accessibility issues were collected as statements by the participants, as the following: “the login button is hidden under a flap that exists only to confuse those who use the system for the first time”, “the system layout is confusing, making it harder to find the information”, “system functions are allocated in a few fields, i.e., there are few options for many options”, and “some fields were confused”.

The users suggested that a simple field on the home page to login directly would ease the task accomplishment and some ambiguous options should be adjusted.

4.3.4 Expert’s perspective
To realize the expert’s perspective, we used indirect feedback, that is gathered by observing users as they interact with Web systems. According to Rocha and Baranauskas [23], the observation method is the most valuable form of collecting feedback about the user interaction, because it may involve valuable discoveries about the users of the system. The ways in which they use the functions of the system is fitted and aspects of the system that can be optimized to make the most effective and efficient use, making users more satisfied, become more evident. Additionally, we analyzed the video collected during the interaction with the users in order to complement the record of observation, as suggested by Nielsen [20].

The issues that were identified during the observation were all related to understanding (or a set of change requirements):

- The screens due to the large number of information.
- The functionality of some menu items because their names were not representative, and a mix of Portuguese and English words.
- The features because of the names and distribution of the menus (not distributed in an intuitive manner).
- What to do when certain features are activated.

These evidences that were observed and related the accessibility issues identified during the interaction with AgendAloca (v1) can discourage its use as a system.

4.4 Threat to the validity of the study
In all experimental studies there are threats that might affect the validity of the results. The threats related to this study were classified into four categories: internal validity, external validity, conclusion validity and construct validity [35].

4.4.1 Internal validity
In this study, we considered two main threats posed a risk of improper interpretation of results: (1) effects of training and (2) user experience. Regarding the first threat, there could be an effect caused by training, if the training of the participants involved in the evaluation of user’s perspective for the first version of AgendAloca had lower quality than the training of participants of the evaluation of version 2. The risk was minimized because both received the same training (AgendAloca version 1 and 2). Regarding the user experience, it was also minimized because both did not know the AgendAloca system.

4.4.2 External validity
The population of participants is not statistically representative, because it is a homogeneous group of undergraduate students. The conduction of the experiment was done in a controlled environment. For these reasons the external validity of this experiment is compromised and the results and conclusions cannot be generalized. Although it is believed that the indicia found in this study is of high validity for the area and the research itself.

4.4.3 Conclusion validity
The amount and homogeneity of the sample are problems for the validity of this experiment, because the amount of subject is not ideal from the statistical point of view and all participants are students of the same institution. Reduced samples represent frequent problems in the field of HCI (Human Computer Interaction) and SE (Software Engineering) [4] [6]. Due to these factors, there is clear limitations in the results, which are considered as evidence of our hypothesis correctness, however are not conclusive.

4.4.4 Construct validity
Participants’ and experiment drivers’ expectations may influence the results. The participants may be influenced by drivers. In this experiment, the participants did not know which of the hypotheses for this risk was mitigated.

5. RESULTS OF THE APPLIED APPROACH
With the problems perceived during the viability study, we listed some accessibility and usability features that were inserted in version 2 of AgendAloca.

5.1 Accessibility features
According to a study conducted by Santos et al. [26] with middle aged people, the learning curve, success rate for doing certain tasks and user satisfaction towards the menu, used in the AgendAloca v1, was ranked with medium score. For this reason, the superfish dropdown menu was chosen as an accessible menu, since it has some aspects that make it more accessible and usable, such as: Indication that there are submenus available with small arrow images. The link corresponds to the whole box area, not just the text. There is visual indication when one item is selected; and the submenus have fade-in and fade-out animation effects when appearing and disappearing and it also has a small shadow.
around it. Furthermore, the superfish submenu keeps open briefly even if the mouse pointer moves out of it; this behavior assists users that have trouble pointing the mouse to one exact place inside a limited space. The superfish menu was evaluated with the best learning curve and received the second best rank according to users [26].

The menu was located in top of the system (Figure 2). However, when the system was tested in aDesigner tool a problem was found: a user that used the keyboard to navigate the system would take too long to make it to the search field. To solve this problem, the menu was placed on the left side of the system (Figure 4), and then to use the keyboard to navigate the system, the search field will be accessed first.

![Figure 4. AgendAloca – version 2](image)

To improve the accessibility of AgendAloca, we focused in solving the issues identified on the four perspective evaluation phases realized on the first version of the system. The issues raised during the evaluations and the accessible design solutions that were implemented in AgendAloca version 2 are presented in the next sections, classified according to the four principles of WCAG 2.0.

5.1.1 Perceivable

In the Perceivable Principle, the guidelines 1.3 Adaptable (1.3.1 Info and Relationships and 1.3.2 Meaningful Sequence) and 1.4 Distinguishable (1.4.4 Resize text and 1.4.6 Contrast) were addressed, as showed in Table 4.

5.1.2 Operable

In the Principle Operable, the guidelines 2.4 Navigable (2.4.1 Bypass Blocks, 2.4.2 Page Titled, 2.4.3 Focus Order, 2.4.4 Link Purpose, 2.4.5 Multiple Ways, 2.4.6 Headings and Labels, 2.4.7 Focus Visible and 2.4.9 Link Purpose) were addressed, as showed in Table 5.

Table 4. Improving the principle Perceivable

<table>
<thead>
<tr>
<th>Guidelines/ Success Criteria</th>
<th>Accessibility problems in the first version</th>
<th>Improvements in the new version</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3</td>
<td>Errors were presented in red without explanation of the meaning to the text.</td>
<td>All colored information has an equivalent in text form, errors are presented in red, and the word “error” will be available in the beginning of the error messages.</td>
</tr>
</tbody>
</table>

Table 5. Improving the principle Operable

<table>
<thead>
<tr>
<th>Guidelines/ Success Criteria</th>
<th>Accessibility problems in the first version</th>
<th>Improvements in the new version</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>Nonexistent.</td>
<td>Added a link “Jump to content” that helps the screen reader users to jump directly to the main content area of the page.</td>
</tr>
<tr>
<td>2.4.2</td>
<td>Nonexistent. The system just shows the system name on the title.</td>
<td>The system name and the purpose of the page are presented in each page.</td>
</tr>
<tr>
<td>2.4.3</td>
<td>When the administrative tab is opened the focus starts from the search box, otherwise it starts from the user menu. Additionally the calendar does not have an instinctive focus order as explained in the item 1.3.2 of Table 4.</td>
<td>The focus starts from the top, and visits all elements from left to right in the pages, when the focus is on the calendar, it travels from beginning to the end of a column before moving to the next column.</td>
</tr>
</tbody>
</table>

The navigation starts from the top of the column, pass by all presentation of that day until reach the end of the column and then jump to the top of the next column, the next day.
There is only one difficult path to execute some tasks, for example for administrators add new users: they need to access 3 different pages, then, in the last one, select a tab to access the register form. All this tasks are available in the main menu or using the search bar.

Use of labels to explain all form inputs but it does not uses headings to explain page/section purposes. Also uses label in all form inputs and uses headings in all main sections/pages to summarize the content.

Nonexistent. All elements show a border when are focused except form inputs that uses the cursor as an indicator of focus.

As commented on the item 2.4.4, that is a Level AA criterion, the first system does not accomplish to it. In consequence, it does not accomplish to this requirement that is Level AAA, which is a refinement of the item 2.4.4.

**5.1.3 Understandable**

In the Principle Understandable, the guidelines 3.1 Readable (3.1.2 Language of Parts), 3.2 Predictable (3.2.4 Consistent Identification) and 3.3 Input Assistance (3.3.6 Error Prevention) were addressed, as showed in Table 6.

<table>
<thead>
<tr>
<th>Guidelines/Success Criteria</th>
<th>Accessibility problems in the first version</th>
<th>Improvements in the new version</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 3.1.2</td>
<td>The standard translation of the CMS does not cover 100% of the content, thus there are some parts of the system where the user can find the content partially in Portuguese, partially in English.</td>
<td>It was created internationalization buttons to change all system content to Portuguese or English.</td>
</tr>
</tbody>
</table>

In different pages, some buttons have the same functionality, but they have different labels. For instance, in the calendar page to filter the type of project the word used is “Apply”. However, in the user page to filter the label is “Filter”.

In both systems it is possible to review input errors after submission. A high score was added to the new system because it is possible review the information after a successful submission. It makes possible recheck and possibly updates the information.

**5.1.4 Robust**

In the Principle Robust, the guideline 4.1 Compatib le (4.1.1 Parsing and 4.1.2 Name, Role, Value) was addressed, as showed in Table 7.

<table>
<thead>
<tr>
<th>Guidelines/Success Criteria</th>
<th>Accessibility problems in the first version</th>
<th>Improvements in the new version</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 4.1.1</td>
<td>After submit the system in the W3C HTML Validator it was noted that the automatic code generation of the CMS generated several elements with the same id.</td>
<td>In the new version due to the little amount of generated code, the majority of the system code was written manually, it makes easy to avoid duplicated ids and to accomplish other specifications of this criterion.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Guideline/Success Criteria</th>
<th>Accessibility problems in the first version</th>
<th>Improvements in the new version</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.2</td>
<td>The login and search forms appear in a panel that slides from the top of the page after the user click the button open panel. This different approach is not identifiable by screen readers, so when the user navigates using the tab key this part of the system is unreachable. The system does not give information to the screen reader deal with this difference.</td>
<td>Standard HTML that works well with screen readers was used in the new system.</td>
</tr>
</tbody>
</table>

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9 [http://validator.w3.org](http://validator.w3.org)
Some characteristics about usability were also improved.

5.2 Usability features

The key to success of any Web system is based on the usability features and improvements done for making them comfortable to users. Therefore, besides the accessibility requirements, usability requirements to mainstream users were also taken into account [8]:

- Initial bar presenting the name of the system to the users identify rapidly the system;
- Searching area of the system, where the user can navigate and search what he/she wishes;
- Information area about the system should be always available (breadcrumb) and
- Applying combination of colors according to motivational patterns suggested by Dias et al. [8].

It is important to highlight that the accessibility and usability requirements were inserted based on the requirements raised with the support of the ACCESSA approach presented in this work.

The same users, who conducted the study in version 1, also did it in version 2. Some user comments on version 2: "I do not think the system has difficulties", "The registration process and viewing registrations is simple and well explained", "The system has easy access with a login screen accessible and all fields are clear" and "The system is very simple to use, has no ambiguous links and is easily used by inexperienced users, and also for people with disabilities". The comparisons between the two versions of the system can be seen in the next section.

6. DISCUSSION COMPARING V1 vs V2

We can perceive that even if users do not report many problems presented in the questionnaires, during interaction with the system many problems are found, according to the quantitative metric analysis. Also, WCAG 2.0 guidelines were not considered while developing the first version of the system, generating some problems during navigation of the users.

To demonstrate the evolution of accessibility of the AgendAloca, the interfaces of the two versions of the system were evaluated following the same principles explained in section 5.2. The inspection’s perspective can be seen in Figure 5.

Figure 5. Evaluation of both versions of AgendAloca according to the WCAG 2.0 guidelines

According to Figure 5, inserting only the accessibility and usability features presented in section 6 in AgendAloca version 2.0 was enough to improve the accessibility and consequently the navigation for the users.

Starting the quantitative metrics analysis (the time taken to perform the proposed tasks, the amount of errors obtained with the interaction of the users, the amount of tasks completed successfully and the number of clicks performed during each task) we can see the comparison between AgendAloca version 1 and version 2.

Figure 6 shows that the time necessary to complete most tasks in version 2 was lower than in version 1. The users saved a long time on tasks, considering the log in functionality, which was significantly reduced in version 2, showing the own data and registering two accounts of students.

Figure 7 shows the number of errors during the evaluation sessions. Task 2 presents the higher rates in this metric (Task – Showing their own data). It occurred because version 1 did not implement a way to visualize the data without showing the data in the form of editing. This behavior misled users while achieving this task.

Figure 8 shows the amount of tasks completed successfully. It is important to acknowledge that, in version 1, only the tasks seeing the group calendar and doing log off were easily completed. The others tasks presented many problems. On the other hand, version 2 presented one hundred percent success rate. This may be a reflection of a well-designed interface and functions becoming more visible.
Figure 8. The amount of tasks completed successfully

Figure 9. The number of clicks performed during each task

All results presented here give us evidence that the new interface is more accessible and more usable than the first version. Although, due to the small sample, it is not possible to consider these results conclusive, we intend to repeat this study with a larger sample and more heterogeneous users, such as people with disabilities. As a result, so far, ACCESSA is practicable and may be useful for the reengineering.

7. FINAL REMARKS

The paper presented an approach (ACCESSA) to rapidly improve the accessibility of existing Web system, acting mainly in interface design without changing the functionality. This is done based on the WCAG 2.0 guidelines and other patterns, choosing the guidelines that are easier to implement and cause more impact on accessibility.

Due the results presents in this paper about two versions of the AgendAloca system, it is possible to assert that the proposal presented in this paper supports the hypothesis that the ACCESSA assists in developing Web applications more accessible. ACCESSA use the methods, which some designers already perform, being practicable and may be useful for reengineering processes.

We intend to continue with the evolution of the AgendAloca system through evaluations with end users, including users with disabilities, through studies on the rate of success and failure in certain tasks, beyond the satisfaction of system utilization. As a consequence of the work presented in this paper, the authors intend to formalize a Web systems developing process. This process will include accessibility in all phases of development (considering the initial phases [8]), when the change costs are lower, may contribute to the development of new accessible Web systems.

8. REFERENCES


