

Exploring WAI-Aria Techniques to Enhance Screen Reader Interaction: The Case of a Portal for Rating Accessibility of Cultural Heritage Sites

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Abstract. Cultural heritage sites (museums, archaeological parks, exhibition spaces, etc.) do not always guarantee accessibility to all users, regardless of their abilities. Often services are not really as usable and functional as expected. Currently there is no website offering accessibility information on heritage sites in a format accessible to all. People with disability or their caregivers are forced to spend considerable time and effort to obtain accessibility information, sometimes encountering difficulties. The Axem portal aims to fill this gap by offering information on the degree of accessibility of cultural sites (museums, archaeological parks, libraries, art galleries, places of worship, exhibition spaces, etc.). It has been designed as a facility for people with disabilities and in general for all individuals who have special needs and require specific services. In this paper the Axem web site is presented as a case study to (1) investigate the use of web techniques for enhancing screen reading interaction, and (2) propose a portal to collect information on accessible services supported by the cultural sites. Regarding web accessibility, the use of WAI ARIA, an accessible web design, is discussed in order to improve screen reading interaction. Accessibility functions and features as well as the ranking algorithm for easy search and the rating mechanism are presented. This work offers a further contribution to the web accessibility field, while proposing a portal which could be exploited by cultural heritage sites and promote their accessible services to people with disability.

Keywords: Accessibility, WAI-ARIA, Screen reader, Cultural Heritage sites.

1 Introduction

Accessibility is crucial for guaranteeing fair opportunities to all regardless of one's ability, at school, work and cultural and social life. About 15% of the world's population lives with some form of disability [1]. This data shows the urgent need to close the access gap worldwide.

In recent years, many researchers have focused on the accessibility of cultural heritage sites. Technology has recently greatly enhanced accessibility for people with disability. Digitization, 3D printing and sensors offer visitors an augmented environment enhancing their perception with an audio-tactile experience [2]. In the last decade, information related to artifacts in museum collections has been increasingly made available to visitors using mobile guides or smartphones via wireless networks, exploiting RFID technology [3,4], or beacons [5]. In addition, 3-D printing enables blind people as well as children, to explore artifact copies that can be touched and handled [6], offering a multisensory experience that enables learning by experience [7]. However, little attention has been devoted to personalizing user experience according to different user abilities when exploring digital resources [8], nor to making accessibility information of cultural sites truly accessible to people with disabilities.

Cultural heritage sites (museums, archaeological parks, libraries, art galleries, places of worship, exhibition spaces, etc.) do not always guarantee accessibility to all users, regardless of their abilities. Often services are not as usable and functional as expected. Currently no web website offers accessibility information on heritage sites in a format accessible to all. People with disability or their caregivers are forced to spend much time and effort to obtain accessibility information, sometimes encountering difficulties.

The Axem website aims to bridge this gap by offering information on the degree of accessibility of Italian cultural sites (museums, archaeological parks, libraries, art galleries, places of worship, exhibition spaces, etc.). It would be an accessible website that delivers information on accessible services of Italian cultural heritage sites.

This paper illustrates the design model driving the creation of the Axem website, its services, accessibility functions and features, the ranking algorithm for easy search and the rating mechanism. Both benefits and limitations will be discussed. Since benefits for people with disability are obvious in terms of saving time and increasing the en-

joyment of a cultural site experience, and are factors that can help orient their visit, the limits merit a brief discussion. The major limit in the spread of the Axem website is persuading managers of cultural heritage sites to provide the metadata related to their accessibility services. Axem aims to offer an environment for promoting an interactive community on accessibility topics.

In this study, the Axem case study is exploited to investigate WAI-Aria techniques used to enhance screen reader interaction. In previous works, WAI-Aria attributes and roles have been applied to enhancing screen reader interaction with Google Docs [9] and Wikipedia editing [10]. Herein, a further study is presented to explore other attributes in the web page design.

In short, this work offers a further contribution to the web accessibility field, while proposing a portal that could be used by cultural heritage sites to promote accessible services and functions to people with disability.

This paper is organized into six sections. Section 2 introduces the related work, and section 3 describes the method driving this study. In section 4 the Axem website is described highlighting new aspects introduced in its design concept, while in section 5 its most relevant features are discussed in detail. Conclusions and future work end the paper.

2 Related work

Information and Communication Technologies (ICTs) can greatly enhance the museum experience [11]. Technology can actually enhance user interaction and stimulate learning in the museum by eliciting emotions, inspiring people and provoking curiosity with the aim of promoting knowledge among users with different backgrounds, interests, and skills [12]. Due to people's diversity and preferences, it is important to deliver a personalized experience in order to increase the possibility of actively involving users [13]. However, the creation of accessible cultural experiences requires a systematic approach, and the possibility of offering equal access to cultural heritage for persons with disabilities is unfortunately still not mature [14].

Kabassi carried out an accurate literature review by analyzing the state of the art of museum websites. In fact, if not appropriately designed to guarantee access for all, technology may create obstacles and

make interaction difficult, causing museums to lose visitors [15]. Considerable research focuses on how to create accessible and usable information for online museums and evaluation of museum websites. Website evaluation frameworks have been proposed by a number of researchers such as those who proposed 35 criteria for museum websites, grouped into six categories: Content, Presentation, Usability, Interactivity & Feedback, e-Services, and Technical, designed for driving experts in implementing inspection evaluation MuseumQual [16].

Museums usually provide visitors with brochures or audio guides. Visits to museums are sometimes boring since it is difficult for museum curators to catch the attention of all visitors and define in advance a tour for all, since interests vary from person to person according to age and interests [17]. Interactive and personalized museum tours can be developed by exploiting the Internet of Things (IoT). The system proposed by the authors can enhance the user experience by delivering not only artwork details such as title, artist, date, but also details of scenes in large paintings aimed at individual visitors or through multimedia walls in the room for a group. The user can store his/her spontaneous feelings and share this cultural experience on social networks. Such an augmented reality application can make the visitor experience more accessible to everyone. The user is equipped with a wearable device, which captures images, able to trigger location-aware services.

One most appealing technology exploited in museums is Virtual Reality (VR). “VR relies on technologies (such as computer science, 3D graphics, robotics, etc.) to create a digital environment in which users feel completely immersed, and with which they can interact” [18].

Besides web accessibility, an increasing number of museums are building accessible services for visitors. For instance, for the blind a number of solutions have been implemented in order to make collections accessible by combining tactile exploration, audio descriptions and mobile gestures [19]. However, one problem is the scalability of these solutions; for instance 3-D printing is still expensive depending on the materials selected and it is difficult to maintain high definition when reproducing large and complex artifacts (on a smaller scale).

Descriptions of items can be provided in Braille (although vocal description maybe more comfortable and rapid when moving around a museum), and AAC (Alternative and Augmentative Communication) is useful for describing artifacts in an accessible way for people with au-

tism, while large readable fonts might facilitate reading not only for visitors with dyslexia, but also for old people and children.

Are all these services really accessible for anyone? Physical and technical barriers can negatively impact on visitors with special needs. People with disability need to look for information when visiting a cultural site, to enjoy their cultural experience. This is time-consuming and can be difficult for a person with an impairment. Autonomy is very important for anyone and crucial for people with disability who are dependent on help of caregivers.

Italy is very rich in cultural heritage sites, offering a vast number of public and private collections. Thus it is important to have a point where services are recorded and can be easily explored.

The Axem website would collect this information to benefit persons with disability and spread the culture of accessibility. In the following, features characterizing this website as well as innovative design items are described in detail.

3 Method

The website has been developed using WordPress, a very popular Content Management System. Accessibility was taken into account from the website's earliest design phases. First of all, the accessibility of the templates made available by WordPress were evaluated. Thus, some templates were first selected according to the layout typology preferred for the Axem website. Next, they were modified to obtain a more accessible and usable layout via screen reader. More specifically, to resolve some accessibility issues encountered while interacting via screen reader, several changes were needed.

Accessibility was taken into account when designing the website. Accessibility requirements by WCAG 2.1 [20] were applied. Despite meeting accessibility requirements, some interaction problems via the screen reader were still encountered. For this reason, some changes to the templates, as well as the WAI-ARIA technology [21] application were necessary to improve interpretation and navigation through screen readers.

More specifically, in WordPress only one standard template and three plugins were installed: Loco Translate¹ (translation editor, <https://it.wordpress.org/plugins/loco-translate/>), Ajax Search Lite² (is a responsive live search engine, which improves the user experience ex-

exploiting Ajax calls, <https://it.wordpress.org/plugins/ajax-search-lite/>) that replaces the default WordPress search engine; PODS³ Plugin to create and manage personalized content (custom post types, custom taxonomies and advanced content types, <https://it.wordpress.org/plugins/pods/>). Then three taxonomies (“Places”, “Services”, “Categories”) and two custom post types (“Cultural Places” and “Ratings”) were created in the website.

The necessary changes were coded via PHP functions which had been integrated with those provided by the CMS (WordPress). Doing this, the types of posts (pages and articles) available in the CMS had been extended so as to have specific pages for the website (data forms and rating system). The result was to offer website features that can be interacted with by the end-user (e.g., the person editing the pages to insert cultural site data) via a graphical interface.

Web Content Accessibility Guidelines (WCAG) and WAI-ARIA (Web Accessibility Initiative - Accessible Rich Internet Applications) functions were applied to simplify the interaction of people using screen readers or having cognitive difficulties.

The intent was to experiment WAI-ARIA to improve the user interface experience, in order to make navigation via screen reader simpler and more effective while keeping the user interface pleasant and graphically appealing.

4 The Axem Website Prototype

The Axem website has been designed as a supporting tool for people with disabilities or temporary limitations, and in general for all individuals who have special needs and need specific services. It is intended to be an information point which connects users with disabilities to facilities, in order to improve the quality and the spread of information about accessible services related to cultural heritage sites. This should encourage cultural centers to become more accessible (through the incentive of an accessibility rate).

For each cultural site, AXEM website is therefore designed to collect information about the services offered for each specific disability. For instance, a museum offers braille labels for blind visitors, but does not have writings suitable for people who require communication via AAC (Augmentative and Alternative Communication). Also, another museum might offer video guides for hearing-impaired people but lacks an

interactive audio guide for those with a vision impairment. In short, any site should include this type of information in their forms to add to the website. Thus, when retrieving the desired information the user can obtain the results according to the type of disability selected in the search form.

4.1 Novel aspects

Axem is a centralized digital gateway for gathering data about the accessibility of cultural heritage sites. The new aspects considered when designing the AXEM website are related to (1) functionalities offered to the user when getting information, and (2) features to enhance the screen reader user interaction with the user interfaces (UIs). In designing the Axem pages, several techniques to improve screen reading interaction have been used and tested.

First, innovative functional aspects of the Axem website include:

- A search procedure based on filters for enabling search according to user preferences -- for instance, the possibility of selecting and retrieving those cultural sites offering a specific accessible service, or located in a geographic area.
- A Review system combined with accessibility aspects.
- A combined algorithm for ranking score processing based on the level of accessibility.

Secondly, regarding screen reading interaction with the user interfaces, the new design aspects include:

- Visual flow differing from what is perceived via screen reader in order to get a more accessible and pleasant visual layout. This feature has been tested for the “about” page and the search results.
- Aural feedback to improve the user experience; this functionality has been applied to the success/failure for the search results as well as when selecting the review score.

5 AXEM Development

5.1 Search interface

The main function of the Axem website is the search, and so this was designed with particular attention (developing a sophisticated algorithm). Figure 1 shows the Search page. The user can access the search by scrolling the home page or clicking the item “Search” on top menu.

The interface is simple and minimal in order to make interaction easy and efficient for all, including via screen reader and keyboard. It displays two buttons in order to offer two different search modalities:

(a) free “Search”, i.e., a text box to edit the cultural heritage place for which accessibility services are desired;

(b) “Search with Filters”, which is composed of a three-item drop-down menu (Category, Region, and City) and four checkboxes for selecting disability type (intellective, motor, hearing and visual disabilities) as shown in Fig. 2.

5.2 Accessibility score

Each cultural heritage site has an accessibility score assigned by an algorithm designed to not penalize sites that for any reason have no accessibility services. The rating reflects the actual quality of the available services, since the evaluation is performed for each service and not globally, as shown below (Fig. 3 and Fig. 4).

The overall rating is the overall mean generated by the arithmetic mean of the scores associated with each service for a specific disability (from 0 to 4). Those scores are defined by the ratings proposed by the users.

The rating system accepts the score and comments related to a single disability per time. This feature differentiates the Axem website from those allowed by other rating systems: to improve accuracy, the scores are based on the user experience of each single service. There is no overall evaluation of the visit.

The review for a cultural site can also comprise more comments to evaluate more services of a disability area.

To this aim, the search form is composed of a title and a checkbox showing the available services by disability category. For any selected

category, a score field and a text box are shown by the interface for inserting data.

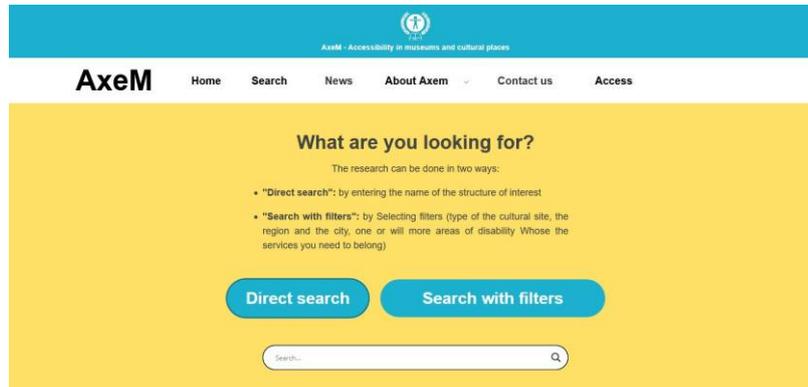
The screenshot shows the top navigation bar of the Axem website with the logo and menu items: Home, Search, News, About Axem, Contact us, and Access. Below the navigation is a yellow section titled "What are you looking for?". It explains that research can be done in two ways: "Direct search" (by entering the name of the structure of interest) and "Search with filters" (by selecting filters like site type, region, and city, and specifying disability areas). Two blue buttons, "Direct search" and "Search with filters", are prominently displayed. Below these buttons is a search input field with a magnifying glass icon.

Fig. 1. The Search Page. Search by name (direct search) or Search by Filters

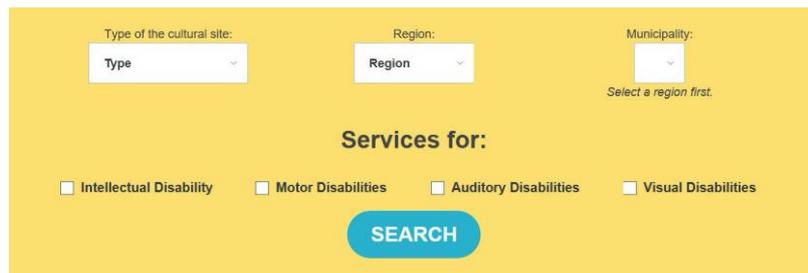
This screenshot shows the "Search by Filters" section of the interface. It features three dropdown menus: "Type of the cultural site:" with a "Type" selection, "Region:" with a "Region" selection, and "Municipality:" with a dropdown arrow and a note "Select a region first." Below these are four checkboxes under the heading "Services for:": "Intellectual Disability", "Motor Disabilities", "Auditory Disabilities", and "Visual Disabilities". A large blue "SEARCH" button is centered at the bottom of this section.

Fig. 2. The Search Page: Search by Filters

5.3 Results and ranking

The “Direct Search” returns the accessibility data related to the target cultural site the user was looking for, while the search with filters produces multiple results, which are ordered with a conditional control on two parameters, arranged then in a decreasing order.

The algorithm acts in this way:

- if a generic search is performed (i.e., no one disability category is selected), results are ordered on the arithmetic mean (scores associated to all disability services offered by the structure);
- if one or more disabilities are selected, results are ordered based on the mean of the relative mean (i.e., the mean of the mean score associated to the selected disabilities).

In practice, this means that the results ranking adapts according to user needs. For example, when no filters are selected, the first result is the Egyptian Museum, showing overall the best average rate (see Fig. 3):

1. Egyptian Museum (overall average of 3.50 with 3 reviews);
2. Museum of Italian Risorgimento (overall average of 3.50 with two reviews);
3. MAO - Oriental Art Museum (overall average of 3.17 with 4 reviews).

When a filter for auditory disability is applied the results order changes (see Fig. 4) since the mean is calculated using the specific reviews related to services for people with this kind of disability:

1. Museum of Italian Risorgimento (average for hearing impairment of 4.50 with two reviews);
2. MAO_- Oriental Art Museum (average for hearing impairment of 3.67 with three reviews);
3. Egyptian museum (average for hearing impairment of 2.50 with two reviews).

5.4 Aural feedback

Aural feedback is very important for blind users. Leporini and Paternò [22] suggest using aural feedback to improve web usability via screen reader. In this perspective, in the Axem site short sounds (different tones) have been associated as feedback of interaction with UI elements. Short tones can drive the user and elicit emotions; each tone has a different goal and is triggered by a specific event:

- selection: confirms that the search radio/check buttons have been selected;
- search: confirms the search is started;
- rating: provides immediate feedback to the user (via an increasing and decreasing tone according to the level of score) while selecting the radio buttons related to the different scores and thus confirms review upload. Specifically, different tones for delivering the number of stars selected for the review: ascending tone for 5 stars, descending tone for 1 star, increasing incrementally adding stars.

Active filters

No filters selected ..

37 results



1) Egyptian Museum

Location: Torino (Piedmont)

Type: Museum

Description:
The Egyptian Museum of Turin is the oldest museum in the world, entirely dedicated to the Nile civilization and is considered, for the value and quantity of the exhibits, the most important in the world after the one in Cairo.

Motor Disabilities

Ramps

Auditory Disabilities

Language Descriptions of the signs

Visual Disabilities

Audio guides Descriptions works or information materials in Braille Embossed Guide

Accessibility

★★★★☆
(3 reviews)

[Go to the site](#)



2) The National Museum of the Italian Risorgimento

Location: Torino (Piedmont)

Type: Museum

Description:
The National Museum of the Italian Risorgimento is the largest exhibition space of Italian national history, the oldest and most important museum dedicated to the Italian Risorgimento. Because of the richness and representativeness of its collections and the only one that officially has the title of "national". Founded in 1878, it is located in Turin inside the historic Palazzo Carignano.

Intellectual Disability

Easy reading Paths for People with Intellectual Disabilities

Auditory Disabilities

Language Descriptions of the signs Opera written descriptions

Visual Disabilities

Audio guides embossed Guide Tactile paths

Accessibility

★★★★☆
(2 reviews)

[Go to the site](#)



3) MAO - Museum of Oriental Art

Location: Torino (Piedmont)

Type: Museum

Description:
The MAO - Museum of Oriental Art is one of the most recent museums in Turin. Located right in the center, it is housed in the historic Palazzo Mazzonis and houses one of the most interesting Asian art collections in Italy.

Intellectual Disability

Paths for People with Intellectual Disabilities

Motor Disabilities

Elevators Ramps Services and tools suited to height

Auditory Disabilities

Interpreter LIS Video with subtitles

Visual Disabilities

Descriptions works or information materials in Braille

Accessibility

★★★★☆
(4 reviews)

[Go to the site](#)

Fig. 3. Search without Filters

Active filters

Museum

with

Auditory Disabilities

9 results 1



1) The National Museum of the Italian Risorgimento **Accessibility**
★☆☆☆ (2 reviews)

Location: Torino (Piedmont)

Type: Museum

Description:
The National Museum of the Italian Risorgimento is the largest exhibition space of Italian national history, the oldest and most important museum dedicated to the Italian Risorgimento. Because of the richness and representativeness of its collections and the only One That officially has the title of "national". Founded in 1878, it is located in Turin inside the historic Palazzo Carignano.

Auditory Disabilities

Language Descriptions of the signs
 opera written descriptions

[Go to the site](#)



2) MAO - Museum of Oriental Art **Accessibility**
★☆☆☆ (4 reviews)

Location: Torino (Piedmont)

Type: Museum

Description:
The MAO - Museum of Oriental Art is one of the most recent museums in Turin. Located right in the center, it is housed in the historic Palazzo Mazzonis and houses one of the most interesting Asian art collections in Italy.

Auditory Disabilities

Interpreter LIS
 Video with subtitles

[Go to the site](#)



3) Egyptian Museum **Accessibility**
★☆☆☆ (3 reviews)

Location: Torino (Piedmont)

Type: Museum

Description:
The Egyptian Museum of Turin is the oldest museum in the world, entirely dedicated to the Nile civilization and is considered, for the value and quantity of the exhibits, the most important in the world after the one in Cairo.

Auditory Disabilities

Language Descriptions of the signs

[Go to the site](#)

Fig. 4. Search with Filters: Auditory Disability

5.5 Enhancing reading flow via screen reader

The most important target of Axem is accessibility. To make the site accessible via screen reader, html native features to provide basic semantic information and WAI-ARIA attributes have been exploited.

Specifically, “aria-live”, for live regions (areas that dynamically change client-side) and “aria-labelledby”, to link objects to their labels assuring the correctness of the announced content have been used. We considered these features while designing the Axem pages. The “About Axem” page is an example (Fig. 5).

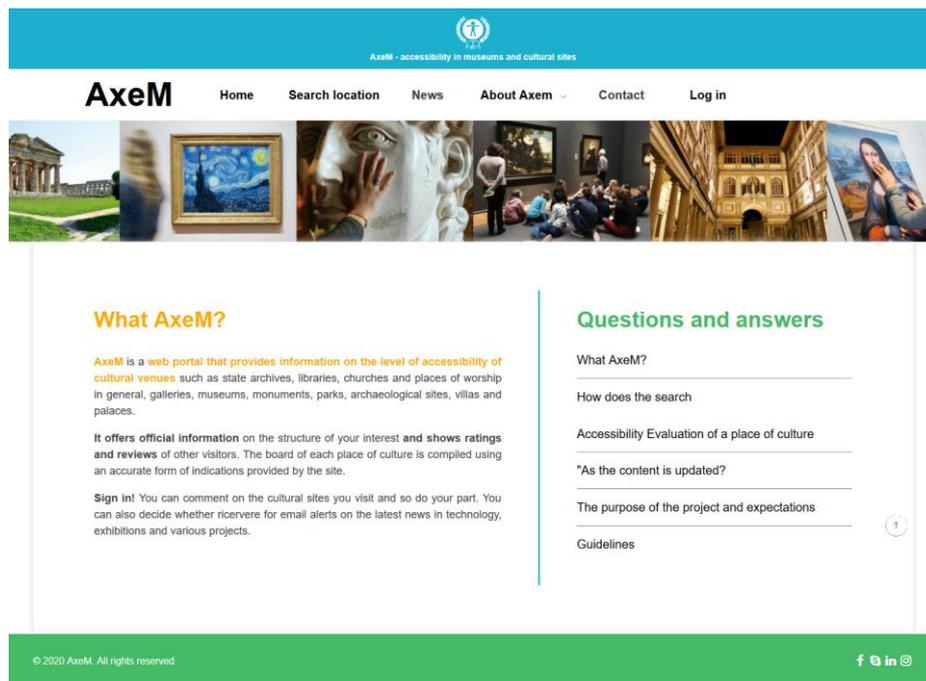


Fig. 5. The ‘About Axem’ Page

The “About Axem” page is structured with two containers: a list on the right side and a text area on the left showing dynamically the content associated to the link selected from the items in the right list. So, visually the current text is shown on the left, while the list of possible choices is on the right. When designing such a structure, the screen reader announces first the current content, and next the right list. In this way, a blind user reads the content beforehand and only afterward the list of all the possible choices to select.

This organization is very functional visually but was disorienting when reading the page via screen reader, which announces sequentially content by first detecting the text on the left and next the menu list on the right. In this way, the user is unable to perceive the appropriate content uploaded according to the user selection on the left. The right logi-

cal order to be perceived should be (1) the list of items, and (2) the main content uploaded according to the item selected from the list.

To fix this problem the <div> elements have been inverted in the order to assure the correct sequence of the reading via screen reader, while the graphical appearance was arranged in the CSS using “float left” and “float right” attributes.

The text appears/disappears thanks to a Java Script function associated with the paragraph id that modifies the “display” element (“block” or “none” value) and links the focus() method to the document object related to the id of the associated text. With "focus" it's possible to move the cursor (focus) on a Web page element. The text section is a live region. In this way, the screen reader user is able to suitably perceive all the dynamically updated content, while the sighted one can see the same nice layout, as no change was made. The figure 6 shows a portion read by the screen reader in the correct order. The words in italics announced by the screen reader to provide information on the user interface.

Also, to facilitate the movement via keyboard, an “accesskey” has been associated with the list. This attribute creates a shortcut for accessing the target item quickly (accesskey="x" tabindex="0").

Figure 7 shows portions of code of the axemscript.js and about.php files.

Main region

Questions and answers

Link What is AxeM?

Link How research works

Link Evaluation of the accessibility of a place of culture

Link How are contents updated?

Link The purpose of the project and expectations

Link Guidelines

Heading level 1 What is AxeM?

AxeM is a web portal that provides information on the level of accessibility of cultural sites such as state archives, libraries,

...

Main region end

Fig. 6. Portion read by the screen reader in a logical sequential order

file axemscript.js

```
...
function visualizza(id){
switch (id) {
case 'testo_scomparsa1':
document.getElementById('testo_scomparsa1').style.display = 'block';
document.getElementById('testo_scomparsa2').style.display = 'none';
document.getElementById('testo_scomparsa3').style.display = 'none';
document.getElementById('testo_scomparsa4').style.display = 'none';
document.getElementById('testo_scomparsa5').style.display = 'none';
document.getElementById('testo_scomparsa6').style.display = 'none';
document.getElementById('titolo1_content_about').focus();
break;
case 'testo_scomparsa2': [...] (for each pop-up paragraph)
```

file About.php

```
<main role="main" class="pagina-about pagina-faq">
<div style="width: 100%; height:200px; display: block; back-
ground:url('<?php echo get_site_url(); ?>/wp-
content/uploads/2019/03/Collage.jpg'); background-repeat:no-repeat; back-
ground-size:cover; background-position: center;"></div>
<div class="row content_single_luogo_cultura">
<div class="col-md-12">
<div class="row">
<!--column 2-->
<div class="menu_about col-md-5 order-md-12" role="menu" access-
key="x" tabindex="0" accesskey="q">
<?php echo '<h1 id="titolo_menu_faq" class="titoli_verdi">' . _(' Questions
and answers
', 'axem') . '</h1>'; ?>
<ul id="menu_about">
<li aria-label="uno" role="menuitem"><a href="#titolo1_content_about"
onclick="visualizza('testo_scomparsa1');"> What AxeM?</a></li>
<li aria-label="due" role="menuitem"><a href="#titolo2_content_about"
onclick="visualizza('testo_scomparsa2');"> How does the search</a></li>
<li aria-label="tre" role="menuitem"><a href="#titolo3_content_about"
onclick="visualizza('testo_scomparsa3');"> Accessibility Evaluation of a
place of culture</a></li>
<li aria-label="quattro" role="menuitem"><a href="#titolo4_content_about"
onclick = "visualizza('testo_scomparsa4');"> As the content is updated?
</a></li>
<li aria-label="cinque" role="menuitem"><a href="#titolo5_content_about"
onclick="visualizza('testo_scomparsa5');"> The purpose of the project and
```

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expectations </a></li>
<li aria-label="sei" role="menuitem"><a href="#titolo6_content_about"
onclick="visualizza('testo_scomparsa6');"> Guidelines</a></li>
</ul>
</div>
<!--column 1 -->
<div class="content_about_testo col-md-7 order-md-1">
<div aria-live="assertive" id="testo_scomparsa1" style="display: block;
text-align: justify;">
<h1 tabindex="-1" class="titolo_content_about" id="titolo1_content_about"
> What AxeM?</h1>
<p> [...] </p>
<div aria-labelledby="titolo_menu_faq"><img style="width: 5px;" src
="<?php echo get_site_url(); ?> /wp-content/uploads/2019/04/bianco.png "/>
</div>
</div>
...

```

Fig. 7. Java Script and WAI-Aria code portion

6 Conclusions and future work

The Axem website has been designed as a supporting tool for people with disabilities or temporary limitations and in general for all individuals who have special needs and need specific services. It is intended to be an information point, which connects users with disabilities to facilities, in order to improve the quality and the spread of information about accessible services related to cultural heritage sites. This should encourage cultural places to become more accessible (through the incentive of an accessibility rate). In this context, users' reviews and ranking are a crucial functionality available in the Axem portal.

Currently, the Axem site structure is complete with its main components and functions. The portal is ready to be populated and tested by curators of places of culture and to be optimized, thanks to the users' feedback.

Concerning the user interface, the WAI-Aria attributes used to enhance screen reader interaction resulted in a suitable solution to be considered when developing accessible web pages and layout. In particular, the two attributes "aria-live" and "aria-labelledby" combined with the property "float left" are useful to design a pleasant graphical inter-

face, while maintaining a logical sequence in reading via assistive technology.

The model used to design the Axem site could also be applied to other domains, such as in the educational context, in which accessibility and usability principles can improve the user experience and make the learning process simpler for people with disability.

Future work will include the development of additional features to support the users in searching and obtaining details and information of the services offered by the cultural site, creating a link with other people in the community, designing public and private communication features, and so on. Furthermore, other WAI-Aria attributes will be explored to investigate additional accessibility features.

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