

# An Enriched ePub eBook for Screen Reader Users

Valentina Bartalesi and Barbara Leporini<sup>(✉)</sup>

CNR-ISTI, via Moruzzi 1, 56124 Pisa, Italy  
{valentina.bartalesi, barbara.leporini}@isti.cnr.it

**Abstract.** Our study aims at obtaining ePub accessibility for all, including screen reader users. Since an ePub document is made up of several (X)HTML files, we analysed and worked with those (X)HTML tags that affect the blind user's experience in the reading. As a case study we developed an "enriched" ePub book which applies technical solutions (i.e. tags and attributes) with the purpose to overcome the accessibility and usability issues observed when interacting via screen reader. In this work we present the results collected through an online survey conducted with 25 users to evaluate the "enriched" ePub compared with the original PDF format in terms of accessibility and usability. Positive responses about the proposed solutions emerged from the survey: the easy access to the table of content, to the images, to the text and also the ease of navigation. In short, 88 % of the users preferred the ePub format instead of the PDF. This confirms that quite simple technical solutions can really improve the reading experience for not only visually impaired people. The results from the survey also showed accessibility issues and limitations of the screen readers and eBook reader software which still exist.

**Keywords:** eBook accessibility · eBook usability · ePub format · Blind users

## 1 Introduction

Nowadays electronic books (eBooks) are increasingly used by everyone, especially on mobile devices. This is particularly important and useful for people who are not able to access the print version, such as the visually-impaired, including for educational purposes [10]. Unfortunately, currently available eBooks don't allow the blind users to properly and satisfactorily read the content via screen reader [11]. The content is usually not well designed, because: (i) the images are not equipped with alternative descriptions; (ii) the table of contents is not available or well-structured; (iii) the organization of the eBook in chapters, sections and sub-sections is not well-designed for effective interaction via screen reader, especially on touchscreen devices.

In our study we took into account the ePub format since it is made up of several (X)HTML files. EPub is a free and open eBook modeled by the International Digital Publishing Forum (IDPF) and it is widely used by the eBook vendors. Several guidelines and criteria have been proposed to support the accessibility and usability for (X)HTML contents (e.g. ePub 3 Accessibility Guidelines, WCAG 2.0). Our aim is to investigate if such guidelines are likewise appropriate for an ePub when interacting via screen reader.

A screen reader is software that allows the identification and interpretation of what is displayed on the User Interface (UI). In this study we focused specifically on the reading of eBooks using the screen reader VoiceOver, especially through mobile devices. Based on the observed issues [4], we worked with those (X)HTML tags that affect the blind user experience in the reading of an ePub book. Our proposed solution aims at enriching the ePub format for satisfactory screen reader interaction, not affecting the visual layout at the same time. Through the Book4All tool [6] – adequately extended with a specific module – we handled three existing books to apply our proposed solutions. Herein we present the results collected through an online survey conducted to evaluate the accessibility of one of our enriched ePub books compared with its PDF original version.

After a short introduction of other works in the field, the case study is presented. Next, we will report the evaluation results collected by the survey.

## 2 Related Works

Several solutions and tools have been proposed to provide valuable support to people who encounter serious difficulties in reading paper-books. The Daisy consortium, for example, develops, maintains and promotes open international DAISY (Digital Accessible Information System) Standards for documents. This form is designed to provide eBooks accessible in both audio and text format. On 11th Oct 2011, ePub3 (= DAISY 4 distribution format) which uses HTML 5 was approved as a final Recommended Specification by IDPF (International Digital Publishing Forum). Thus the publishers' standard and accessibility format has been integrated to achieve accessibility in the mainstream eBook industry.

Some studies have been investigated for how the reading can be improved. Adjouadi et al. [2] introduce an automatic book reader for blind people: a fully integrated system with a high reading accuracy. In particular, concerning the state of art reader devices actually available, [9] an evaluation in usability and accessibility perspective is presented. El-Glaly et al. [7] present a novel interaction for reading texts depending on situated touch. Using an iPad, the text of an eBook is rendered audible in response to the user's touch. Attarwala et al. [3] propose the tablet-based e-reading application ALLT which enhances the capabilities of older adults and visually impaired e-book readers through customizable and intelligent accessibility features. Bottoni et al. [5] propose a system to support the users' interactivity for editing, annotating, and indexing e-documents. On the other hand, various tools that aim at generating and adapting the eBook content have been proposed. The Starlight platform [8] allows the users to develop and interact with electronic textbooks. The Starlight platform is composed of two tools: (a) the "Reader", for interactive delivery of electronic textbooks combining visual, acoustic and haptic modalities; and (b) the "Writer", a tool for producing eBooks supporting editing facilities.

Henry [12] reports a study on text-customization needed by visually-impaired users for reading PDF documents. The results encourage better text customization functionalities in the reading tools. AbdelRazek and Modayan [1] describes the importance of the eBook content adaptation when compared to a simple digital version. The adaptive

eBook resulted more accessible and usable in terms of content navigation. Our approach aims at exploring new opportunities to use the widespread ePub format via common reading tools.

### 3 Accessibility Issues

As discussed in [4], the main problems experienced by blind users when accessing the eBook contents may be especially due to:

1. Lack of context – i.e. accessing only small portions at any one time, losing the overall current content;
2. Information overload – unchanging portions (such as the page header, the page number, etc.) may overload the reading and slow down content exploration;
3. Excessive sequencing in reading the information – reading may force access of the (long) content sequentially if no specific mechanism is applied.

Based on these issues, the most important eBook requirements we considered for blind people can be summarised in:

- a logical order in the reading of eBook content (that is the same order of the sighted users);
- a correct linearization of tables and lists;
- an accurate detection of the images by reading their alternative descriptions, if any, and their captions;
- a suitable communication to the user about the type of the elements (e.g. titles, lists, etc.);
- a simple and quick navigation within the content.

Unfortunately these aspects are not well considered when generating ePub documents by means of automatic tools. The (X)HTML code of an ePub is often not standard or not well-formed. In the same way, the table of content, created by conversion tools, are often incomplete and with broken links. Consequently, the screen reader does not interact appropriately with the content. For example, VoiceOver when reading an ePub is not able to inform the user about the presence of images or titles: it just reads the caption and alternative descriptions, but it does not give any detail on the item type (i.e. if it is an image caption or a title). In addition, even though a heading level (i.e. <h1>, <h2>) is applied to titles, no gesture is available to skip from one title to another (for example, as is laid out in a Web page). Concerning images, other specific usability issues were observed in [4]:

1. When encountering more than one consecutive image, the content is not read appropriately: i.e. the alternative descriptions are read before all the captions (e.g. Image-ALT-text1, Image-ALT-text2, Caption 1, Caption 2).
2. No particular issue for images located in the same page and with text in the middle of them, but it is not easy to understand if the read text is a figure description, a caption, or textual content.

Other similar issues are related to tables and lists. The screen reader is not able to appropriately inform the user about the semantics of the ‘list’ and of the ‘table’ elements (e.g. it does not say “table” when a table is encountered).

To solve these kinds of problems we suggested adding a word before titles, tables and lists to describe the element. Such information can be added via a hidden label that can be detected by the screen reader but that is not visible to everyone. This solution lets us preserve the eBook layout while the screen reader is able to announce additional information to a blind user (e.g. semantic information).

## 4 The Case Study

### 4.1 Method

In order to evaluate our proposed solutions, aimed at overcoming the issues summarized in the previous section, we selected an eBook – the PDF book *Storia Illustrata di Firenze* (*Illustrated History of Florence*)<sup>1</sup> – as a case study. The eBook was chosen according to the following aspects:

1. the table of content as a book structure that has several chapters in order;
2. a number of images to be managed by assistive technologies and small screens;
3. ordered and unordered lists to evaluate how the screen reader is able to easily interact with them.

We especially focused on those aspects that affect the (X)HTML code by arranging the appropriate tags and attributes to have an accessible and enriched ePub output version.

In this work we present the results of a survey conducted to collect further suggestions and comments by end-users on the interaction with both ePub and PDF versions in order to compare their accessibility and usability. According to the requirements described in Sect. 3, the survey investigated the content perception and user interaction. We developed an accessible online survey via Google Docs. Thus we sent to the participants, via e-mail, the URL of the ePub and PDF versions to be evaluated plus the address of the on-line questionnaire. The potential blind users were found thanks to collaboration with the Italian Association for the Blind in Tuscany. To collect comments on the visual user interface, sighted people were involved in the evaluation. The users were asked to interact with the two eBooks by assigning them some tasks in order to focus on specific text portions or book elements. In particular, the users were asked to interact with the table of contents, chapters and sub-chapters, images and lists. Questions were asked based on the aspects considered in the tasks carried out by the users. The results of the evaluation are reported in Sect. 5.2.

Figure 1 shows two pages from the ePub *Illustrated History of Florence*.

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<sup>1</sup> Cardini, F. *Storia illustrata di Firenze*. Pacini Editore, Pisa, Italy (2009).

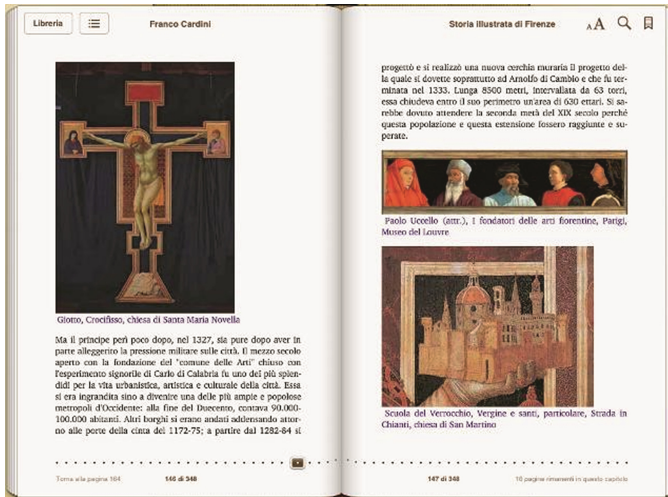


Fig. 1. Two pages of ePub with images, captions and text

## 4.2 A Tool to Support eBook Generation

To generate our case study eBook, we used the automatic procedure designed for the Book4All tool [4]. Book4All is a tool designed to support the adaptation of PDF documents into three accessible formats for blind users: XHTML 1.0, DAISY 3.0, and ePub 3.0. The tool extracts text and images from the PDF source. Later, an operator can manually manage images, tables, and content by (1) adding descriptions (i.e. 'ALT' attribute) for each image; (2) by managing the table code and structure; and (3) adding content. Once the content has been edited, the operator can export the result into the three supported formats. In particular, the tool supports the following operator's actions:

**Table of Content.** For the content structure we used Heading Levels. The H1 tags were considered as criterion to automatically create a navigable table of content.

**Titles and Headings.** Headings can be useful to structure the contents and move through the sections as well. As recommended by the ePub 3 Accessibility Guidelines, we included only a single heading in each chapter. Unfortunately some screen readers, like VoiceOver, are not currently able to detect them in an eBook. A possible solution to inform the reader about titles could be to add the hidden label "title 1" before each title (i.e. H1 tags). This solution has been applied to our case study eBook.

**Images.** Following the ePub 3 Accessibility Guidelines and WCAG 2.0, when the images were central to the understanding of the content we always included an alternative text in their alt attribute. However some screen readers for the mobile have some issues when reading consecutive images. To this end, the proposed procedure arranges the source code so that the screen reader reads correctly the contents also in presence of

images. In particular, the tool applies a solution suitable for two consecutive images, by embedding each image (i.e. the `<img>` tag) and caption (i.e. `<span>` tag) in a single anchor tag (i.e. `<a>` tag). In addition, in order to announce to the reader that an item is an image, we applied the solution based on the hidden label: each image is marked with the hidden word “image”. Such word is not displayed thanks to a specified CSS class but it is readable via screen reader. Figure 2 shows how VoiceOver can interpret the content when there are two consecutive images.

What VoiceOver reads	Related HTML code
Image: Sandro Botticelli, Venus and Mars, particular with Mars sleeping, London, National Gallery  Image: Sandro Botticelli, Lamentation over the Dead Christ, with san Gerolamo, san Paolo e san Pietro, Monaco, Alte Pinakothek	<pre>&lt;p&gt; &lt;a&gt;   &lt;img     src="../../images/pagel94/Venere.png"&gt;&lt;/img&gt;&lt;br/&gt;   &lt;span id="hidden"&gt;Image:&lt;/span&gt;   &lt;span&gt;Sandro Botticelli, Venus and Mars,     particular with Mars sleeping, London, National     Gallery&lt;/span&gt; &lt;/a&gt; &lt;/p&gt; &lt;p&gt; &lt;a&gt;   &lt;img     src="../../images/pagel94/Compianto.png"&gt;&lt;/img&gt;&lt;br/&gt;   &lt;span id="hidden"&gt;Image:&lt;/span&gt;   &lt;span&gt;Lamentation over the Dead Christ, with san     Gerolamo, san Paolo e san Pietro, Monaco, Alte     Pinakothek &lt;/span&gt; &lt;/a&gt; &lt;/p&gt;</pre>
...text content...	
Image: The painting is part of a cycle on the life of Saint Peter, and describes when Jesus directs Peter to find a coin in the mouth of a fish in order to pay the temple tax.  The Tribute Money, fresco in the Brancacci Chapel, Santa Maria del Carmine, Florence  ...text content...	<pre>&lt;p&gt; &lt;img src="../../images/pagel6/Ghirlandaio.png"   alt="The painting is part of a cycle on the life   of Saint Peter, and describes a scene from   the Gospel of Matthew, in which Jesus directs   Peter to find a coin in the mouth of a fish in   order to pay the temple tax"&gt;&lt;/img&gt;&lt;br/&gt;   &lt;span id="hidden"&gt;Image:&lt;/span&gt;   &lt;span&gt;The Tribute Money, fresco in the Brancacci   Chapel, Santa Maria del Carmine, Florence&lt;/span&gt; &lt;/p&gt;</pre>

Fig. 2. How VoiceOver can read images

5 Evaluation

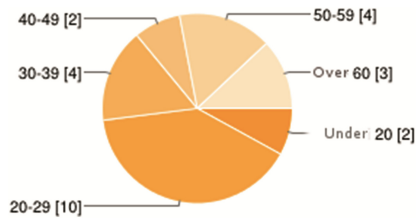
5.1 The Online Survey

The survey included 35 questions about the most accessible aspects. After a brief overview to identify the sample, we focused our attention on comparison of the following aspects of the ePub and PDF formats: assistive technology usage, eBook favorite formats (electronic versus audio books), eBook navigation usability, and access to the content using different eBook readers (both for desktop and mobile devices). A specific attention put was on accessibility/usability of images, section titles and table of contents. Questions were presented through multiple choice and text area. The same questions required a personal judgment on selected features. A Likert 5-scale values from 1 (totally positive) to 5 (totally negative) was used to express the opinion.

## 5.2 Participants

We collected suggestions and comments from 25 users; some of them did not answer all the questions. Our sample included 16 females and 9 males.

70 % of the participants were in the range of 21–59 years old, 20 % were people over 60, and 10 % were under 20. More details are reported in Fig. 3.



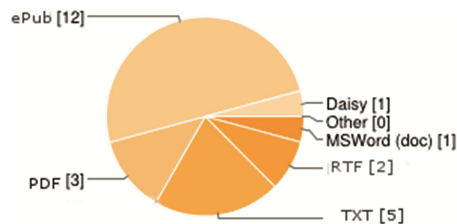
**Fig. 3.** Age distribution of the users

Regarding the type of disability, 14 users are blind, 4 low vision-impaired, and 7 sighted. 56 % of the participants used a screen reader as assistive technology, 4 % used the Easy Access to Windows, 4 % used a screen magnifier, and 4 % used the combination between a screen reader and a screen magnifier; the remaining 28 % didn't use any assistive technology.

Concerning technological skills, 47 % declared to regularly use iPhone 4 or higher, 19 % an iPod touch 4 or higher, 16 % an iPad, 16 % a smartphone with Android, and one person used a tablet with Android.

## 5.3 Results

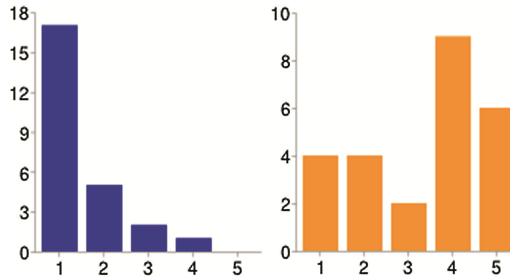
The preference of the eBook usage is confirmed by the collected data from the books format: 64 % of the users usually read electronic books, 12 % listen to Audiobooks, while the remaining 24 % prefer the paper version. With regards the favorite eBook formats, the participants expressed: the ePub with 50 % of users, TXT with 21 %, PDF with 13 %, RTF with 8 %, and finally MSWord and Daisy with 4 % respectively (see Fig. 4).



**Fig. 4.** Preferred eBook formats by the users

With reference to the ePub evaluation, as shown in Fig. 5, the users expressed a positive opinion. The overall score for the eBook usage was '1' (not difficult) according to the

17 users (68 %), '2' according to 5 users (20 %), '3' according to 2 users (8 %), and '4' according to 1 user (4 %). No one expressed a totally negative opinion (score '5').

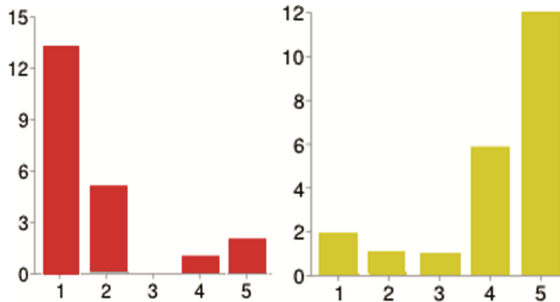


**Fig. 5.** Difficulty degree to access the content for the ePub and PDF, respectively (1-not difficult to 5-very difficult).

On the other hand, regarding the PDF navigation, 6 users (24 %) expressed a totally negative opinion choosing the value '5', 9 users (36 %) chose the value '4', 2 users (8 %) chose the value '3', 4 users (16 %) evaluated the navigation with the value '2', and only the remaining 4 users (16 %) assigned value '1'.

64 % of the users asserted that the ePub document structure is very easy to understand (score equal to 1). Only 9 % of the users expressed the same evaluation regarding the PDF file.

Regarding the navigation, 14 users (64 %) used the table of contents to navigate the ePub document without problems (score equal to 1). Only 2 users (9 %) chose the value '1' for the navigation using the index in the PDF file. More details are reported in Fig. 6.

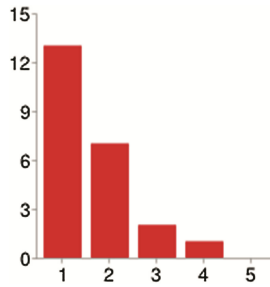


**Fig. 6.** Usage of the table of content (ePub and PDF, respectively)

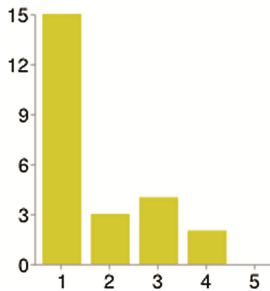
Relating to the PDF book, 80 % of the blind users declared they were not able to identify images in the text. The same percentage asserted also that the screen reader was not able to read the images and their captions in the correct order.

On the contrary, as reported in Figs. 7 and 8, the users declared to perceive the images well (57 % expressed '1' that is no difficulties, 30 % '2', 9 % '3', and 4 % '4') and their descriptions (63 % expressed '1', that is no difficulties, 13 % '2', 17 % '3', 8 % '4') in the ePub book.





**Fig. 7.** Difficulty degree to detect the images in the ePub book



**Fig. 8.** Difficulty degree to detect the captions in the ePub book

Several users commented that long descriptions could be useful just for specific cases; for example when an image is a key element to understanding the text content. Other users suggested using a short description by default and a longer one available on demand. Some users also observed that a mechanism to “include” or “exclude” the images along with the content could be a useful functionality to simplify the reading.

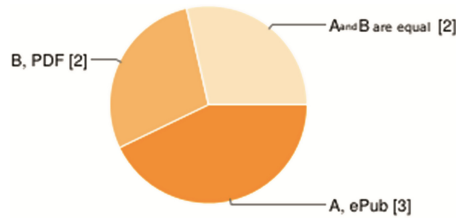
Regarding the titles of the text sections, the blind users declared they were able to detect them well thanks to the (hidden) label “title” before each heading. Blind users also suggested considering the opportunity to skip from a heading to another one as it happens for the Web pages. Although the tags `<h1>`, `<h2>`, etc., have been applied to the eBook source code, the screen reader (for both desktop and mobile devices) is not able to detect them. In fact, concerning headings and titles, several issues were reported by the users when reading, also through the Adobe Digital Edition (ADE 4.0) tool.<sup>2</sup> The users were not able to correctly skip from one section to the next via the commonly preferred command “h” offered by the screen reader Jaws<sup>3</sup> or via any other reader command available in the ADE tool. Although the most recent version of ADE (i.e. 4.0) includes more accessibility features than the previous versions, the majority of them cannot yet be supported, like the use of headings as logical partitioning of the Web content. However, headings allow the users to get an overview of the contents through

<sup>2</sup> <http://www.adobe.com/it/products/digital-editions.html>

<sup>3</sup> <http://www.freedomscientific.com/products/fs/jaws-product-page.asp>

a hierarchical structure available in the ADE tool, which makes possible to get an overview of the contents and navigate among them. This has been observed for both ADE versions for Windows and Mac. There is a similar issue is for the images. There is no mechanism used to detect graphical items to make them accessible to the assistive technologies. The users were able to detect both images and titles only thanks to the hidden labels (i.e. ‘image’ and ‘title’).

Seven sighted users participated in our survey. Their comments were positive, especially about the eBook navigation and the access to the content. All users highlighted the friendliness of the reading activity. One of them also remarked the usefulness of the index to have a direct access to the eBook chapters. Even though we added hidden information to “enrich” the content (i.e. “image” before the <img> tag, or “title” before the chapter and sub-chapter), the comments of sighted users confirmed that our solution does not influence the layout, the image view and the reading of the content. In fact, no non-blind person reported to have encountered anything unusual or particular when showing the images and titles of chapters and sections. Furthermore, for the sighted users the ePub format is preferable to the PDF one, because the text size can be easily and better magnified. However, for most of them the preferred format to read a book is the paper version. Generally speaking, as reported in Fig. 9, for sighted users there is no significant difference between the ePub and PDF format. In fact, 43 % of them replied that “ePub” as the easier format to use, 29 % indicated the PDF to be easier and the rest stated that they are equally easy to use, although 85 % of them observed some differences between the two formats, such as image detection, availability of the content index, title announcement and document lightness as well.



**Fig. 9.** Preferred formats by the sighted users (either PDF or ePub)

## 5.4 Discussion

We focused on evaluating those (X)HTML tags affecting the main interaction aspects, e.g. headings for structuring the content, alternative descriptions for the images, presence of a table of content. Even if the ePub format is complete with accessibility standards, several problems in detecting the semantic of text objects by the screen reader are still present in the ePub books. Thus, we proposed to apply simple tags and attributes to add useful semantic information (e.g. hidden labels) to make the content more understandable by blind users who use assistive technologies.

The users expressed positive comments on the evaluated eBook. However, the responses collected by the survey, revealed also some limitations by the assistive

technologies and eBook reader applications in supporting a satisfactory reading. At the same time, the users suggested some aspects to improve the reading interaction. In brief, the suggestions are related to:

- applying short alternative descriptions for the images, and use more detailed explanations for crucial images;
- making available mechanisms for the assistive technology in order to (1) facilitate structure navigation (section by section), (2) include/exclude image visualization, (3) detect element type (i.e. image, table, title).
- providing functionalities for the eBook reader in order to (1) quickly and easily use the table of contents, (2) show/hide more complex objects like images and tables, and (3) easily read the notes. This requires that assistive technologies as well as reading applications must be able to support: (i) detection of elements type (e.g. recognition of semantic tags or attributes); (ii) more customizable image management (e.g. via specific mechanisms); and (iii) exploitation of content structure (e.g. via table of contents and heading navigation). On the other hand, developers should be able to use specific (X)HTML semantic tags and attributes, which are adequately supported by the applications.

## 6 Conclusions

In this work we presented a survey conducted on ePub eBook interaction via screen reader to collect suggestions and comments on a possible solution proposed to overcome the accessibility and usability issues observed when reading a book on a mobile touchscreen device via screen reader. We used the eBook *Illustrated History of Florence* as a case study to apply and evaluate some technical solutions to improve the blind user interaction.

We had a total of 25 users of which 18 visually-impaired and 7 sighted. Positive responses on the ePub emerged from the survey: 88 % of the users preferred such format. More than 60 % expressed a satisfactory opinion for the navigation (64 %) and for image descriptions and detection as well (63 %). On the other hand, the PDF format has not been appreciated in the same way. The comments of visually-impaired users were positive, especially about the access to the content, the reading of the images and the detection of the titles. All users highlighted the friendliness of the reading activity. We also included the answers given by the sighted users because they revealed some interesting usability aspects of our eBook when it is read without an assistive technology. The sighted user experience confirmed that the features added to improve screen reader interaction do not influence the visual layout, or the image rendering or the reading of the content. Some limitations by the screen reader should be considered by developers when updating the available versions.

Other features and functionalities should be further investigated in terms of accessibility, such as how to underline, highlight and read text with specific characteristics (e.g. text in bold, italic, highlighted, etc.). Novel gestures to carry out more specific actions need to be further investigated. We plan to extend our study in this perspective.

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