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Enhancing e-book accessibility

Insights from user practices and needs across different communities

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This research aimed to understand the user experience with e-books among mobile device users and the needs of blind and partially sighted e-book users. It sought to answer: How do these users access e-books? What are their typical reading practices? What are the special needs of blind and partially sighted users? How does file format affect their reading experience? What mobile devices do they prefer?

For this purpose, surveys were conducted using two questionnaires developed with 1KA software. Translated into the languages of EODOPEN project partners, they were distributed among users from 15 partner organisations in 2020. The results were analysed using PSPP, a free alternative to SPSS.

The findings provide a comprehensive understanding of e-book reader preferences, behaviours, and challenges. Digital libraries are preferred for accessing e-books. Both groups favour offline reading sessions longer than 30 minutes, with structured navigation being crucial. PDF is the most favoured format, followed by EPUB. Preferences vary by visual impairment, with some preferring text-only formats like TXT and RTF. Notebooks and smartphones are popular devices among both groups.

e-books, accessibility, user behaviour and needs, mobile device users, blind and partially sighted users

Detailed summary

Purpose: **The purpose of the presented research was to gain insight into the user experience with e-books among users of mobile devices and to understand the needs of blind and partially sighted e-book users. The research aimed to answer the following questions: How do users of mobile devices and blind and partially sighted users typically access e-books? What are the usual reading practices of these two communities when using e-books? What are the special needs of the blind and partially sighted communities regarding e-books? How does the file format affect the reading experience of both communities? And what are the mobile devices mostly used by both communities of e-book readers?**

Methodology/Approach: **The surveys were conducted using two questionnaires developed with the 1KA software. After being translated**

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into the languages of the EODOPEN project partners, they were distributed among users from 15 partner organisations during 2020. The collected results were analysed using PSPP, a statistical analysis tool developed as a free, open-source alternative to SPSS.

Results: The survey findings offer a comprehensive understanding of the preferences, behaviours, and challenges faced by e-book readers, including both individuals using mobile devices and those who are visually impaired. In terms of access modes, digital libraries are the preferred choice for both mobile device users and visually impaired respondents, with many opting to borrow or download e-books. Regarding reading habits and accommodating special needs, there is a pronounced preference for offline reading sessions lasting longer than 30 minutes, with structured navigation being essential for many users. File format preferences vary among users, with PDF being the most favoured, followed by EPUB. Preferences also differ among different categories of visual impairment, with some preferring text-only formats such as TXT and RTF, while others, similar to mobile device users, prefer PDF and EPUB. Preferences for mobile devices also vary, with notebooks and smartphones being popular choices for both user groups.

Research limitations: The surveys were conducted among users from only 15 EODOPEN partner organisations. For a more comprehensive European perspective, it would be beneficial to extend the study to include other European countries. Additionally, since this type of research was conducted for the first time, there were no prior similar experiences to draw upon. The significant difference in the number of respondents from both communities also makes direct comparisons challenging.

Originality/practical implications: This study represents the first of its kind in Europe. The findings provide valuable insights into the use of e-books and related technologies.

"The EODOPEN project is a collaboration between 15 European libraries from 11 countries."

1. Introduction

Since 2006, two European projects[1] led by the University of Innsbruck have been developed, resulting in the creation of a highly popular digitisation service as E-Books on Demand (EOD). This service offers on-demand digitisation of library works which are in the public domain, mostly published between 1500 and 1900. Today, nearly 40 European libraries provide this service. Users only cover the costs of digitisation, which are comparable to photocopying costs or even less.

However, this service has certain limitations. It does not include modern, copyrighted works, and the output file format is typically a version of PDF. In response to these challenges, former consortiums partners submitted another project proposal to Creative Europe Culture Sub-programme titled E-books-On-Demand-Network Opening Publications for European Netizens (EODOPEN). The project successfully passed the European Commission evaluation and commenced on 1 November 2019.

The EODOPEN project is a collaboration between 15 European libraries from 11 countries.[2] It is coordinated by the University of Innsbruck in Austria and co-financed by the European Commission under the Creative Europe initiative. Due to the Covid-19 pandemic, the project has been extended for an additional year, concluding in October 2024.

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"The European Blind Union ... estimate that in Europe approximately 30 million citizens in Europe have visual impairment, with 90% of them being over the age of 65."

The main goal of the project is to offer public access to publications from library collections spanning the 20th and 21st centuries. In contrast to other digitisation efforts, the EODOPEN partners concentrate on digitising copyrighted publications and endeavour to ensure easy access for communities that have encountered challenges in accessing such materials. Typically, digitised publications are outputted in PDF format, which caters to the requirements of users on mobile and small devices, as well as those in the blind and partially sighted communities. Similar findings were reported by Ba Matraf et al. (2023).

Within the project, a working group led by the National and University Library of Slovenia, was dedicated to analysing the needs of e-book readers in two different communities: users of mobile devices and the blind and partially sighted users. Accessibility to e-books for these communities typically depends on delivery formats used for digitised materials. To address this, the EODOPEN project conducted four different surveys. The first two analysed the special needs of the users of mobile technologies and the blind and partially sighted communities. The third survey focused on analysing the delivery formats resulting from digitisation and their impact on the quality of optical character recognition (OCR) outputs, in relation to project partners' workflows. The findings were published in Kavčič Čolić and Hari (2024), and Hari (2021). The fourth research was dedicated to the implementation of file format conversion services, and the results are currently under analysis.

In this paper, we delve into the needs and technical requirements of e-book readers when utilising mobile technologies, which were the focal points of the initial survey. The survey served as a starting point for the development of the guidelines and recommendations outlined in Guidelines and recommendations for the provision of alternative and special formats (Kavčič Čolić et al., 2022) (Project Deliverable no. 11). The results gathered for these guidelines are presented here for the first time.

Throughout this paper, we refer to **mobile devices** as encompassing smartphones, notebooks, tablet computers, and e-readers. According to Ba Matraf et al. (2023, p. 421), an **e-book** is defined as „(…) a book in an electronic format, which can be beneficial to all readers, mainly those struggling with print books because of their vision impairments."

When we mention **users**, we are referring to customers of library services. Our research targeted two communities of users: those utilising mobile devices and library services, and those who are blind or partially sighted.

By **digitisation**, we refer to the digital conversion of information from analogue carriers. Nearly every European library has participated in some form of mass digitisation project. However, the digitisation outputs of such projects are typically accessible only through PDF or other non-responsive file formats. This poses challenges for accessing content on mobile devices with small screens, and especially for visually impaired individuals.

The European Blind Union (EBU) uses the term „vision impaired" to collective denote blind, visually impaired, or partly sighted individuals. They estimate that in Europe approximately 30 million citizens in Europe have visual impairment, with 90% of them being over the age of 65.[3]

The World Health Organisation (WHO) notes that „Eye conditions common in the [European] Region include refractive errors such as myopia, cataracts, age-related macular degeneration, diabetic retinopathy and glaucoma. Uncorrected refractive errors and cataracts are the leading causes of vision impairment in the Region."[4] Through the text, we primarily use the term **‚blind and partly sighted users'.**

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2. Literature survey

The research conducted during the EODOPEN project encompassed several areas, including the utilisation of mobile devices, digitisation practices, such as file formats outputs and OCR quality, and accessibility for the blind and partially sighted users. Subsequently, we present a literature review addressing related research in these fields.

According to Eurostat,[5] in 2023, 90% of internet users accessed the internet via mobile devices, with 85% using mobile or smartphones and 63% utilising tablets or laptops. Mobile devices account for approximately half of web traffic globally. In the last quarter of 2023, excluding tablets, mobile devices generated 58.67% of global website traffic, consistently maintaining around 50% since early 2017 and surpassing it in 2020.[6]

According to GSMA,[7] in 2022 there were approximately 496 million unique mobile subscribers in Europe, with a penetration rate of 90% of population. It is projected that in 2030, this number will rise to 507 million, with a penetration rate expected to reach 92%.

Mobile devices have become an integral part of everyday life for Europeans, and we anticipate that they will increasingly dominate as the primary technology for accessing information, including digitised content, in the future.

Recognizing this trend, we observe the adaptation of European regulations, such as EU Directive 2016/2102 on the accessibility of websites and mobile applications of public sector bodies, and Directive 2019/882 on accessibility requirements for products and services, including e-books, e-book stores and loaning sites. While Directive 2019/882 primarily targets publishers to create born-digital accessible e-books, it also encourages organisations such as libraries and cultural institutions to implement necessary changes to enhance accessibility in their practices. This directive has spurred numerous initiatives aimed at facilitating the creation of accessible publications.[8]

The number of mobile devices users is increasing not only among individuals without visual impairments, but also among the blind and partially sighted individuals. Many authors (Martiniello et al., 2022; Abraham et al., 2022; Christy and Pillai, 2021; Pandey et al., 2023) have noted an increase in the use of smartphones and tablets as assistive technologies by people with visual impairments, replacing traditional visual aids. McNaught and Alexander (2014) suggest that e-books have the potential to address a wide range of accessibility needs, including magnification with text reflow, colour/contrast adjustments, text-to-speech support, and alternative texts for image/tables, making them compatible with assistive technologies. The text-to-speech functionality allows users to listen to text in e-messages, internet and e-books (Mishra, 2023), with screen readers commonly utilised by blind or partially sighted individuals, including for accessing e-books (Momotaz et al., 2023). These solutions significantly contribute to the digital inclusion of blind and partly sighted people (Alabi and Mutula, 2020). As digital natives, the generations born in the digital era are accustomed to and heavily reliant on digital devices, indicating that this technology will remain integral to their futures.

E-books are compatible with a wide range of mobile devices, including e-readers such as Kindle, Kobo, Midia Inkbook, and NOOK, as well as smartphones, tablets, and laptops. The choice of file format and accessibility features depends on factors such as the device type (screen size, display quality) and the platform used (commonly Microsoft, Mac, Android, and iOS).

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"Only approximately 7% of published works are provided in accessible formats for print-disabled individuals. In developing countries, this percentage drops even lower, to less than 1%."

Larger-screen devices typically have no trouble accessing PDF files. However, PDFs lack responsiveness, making them less ideal for smaller devices like smartphones or e-readers. Different platforms offer varying support for file formats. For instance, Kindle e-readers did not originally support EPUB format, so users had to convert EPUB files to AZW/MOBI format before uploading them to their devices. Recently, however, due to new developments at Amazon, file format conversion to EPUB has been made available to users, while the obsolete MOBI format is no longer supported (Amazon, s.a.). Additionally, for blind and partially sighted users, Android devices can accommodate the DAISY reader and other accessible applications.

Currently, many European libraries are focused on providing virtual access to their collections. In the first decade of the 21st century, the European Union and national financing institutions co-financed mass digitisation projects. While these projects yielded rich digital collections, they were often accessible only in non-responsive formats. The critical component for accessing digitised content was the text obtained through OCR processing. Digitisation processes typically involved scanning into archival formats, such as JP2 or TIFF, followed by the production of accessible PDF files. These formats served as the basis for OCR processing. Consequently, the OCR quality was often suboptimal, reaching no more than 90% accuracy compared to the ground truth. Concerning blind and partially sighted, such digitised material was often inaccessible due to lack of clean text, correct reading order, navigation, structure or possibility to adapt the visual presentation of the text according to their needs.

In addition to technical solutions, numerous regulations and recommendations have been adopted to enhance accessibility for blind and partially sighted users. One of the most significant is The Marrakesh Treaty to Facilitate Access to Published Works for Persons Who Are Blind, Visually Impaired, or Otherwise Print Disabled (The Marrakesh Treaty), which was adopted in 2013 and entered into force in 2016. Today, it is an integral part of the body of international copyright treaties administered by the World Intellectual Property Organisation (WIPO). The Treaty aims to facilitate access to published works for individuals who are blind, visually impaired, or otherwise print disabled (Dreyling and Hackett, 2022; Ferri, 2023; Coates et al., 2018).

More than 90% of all published materials remain inaccessible to the blind and partially sighted (Marrakesh Treaty, 2024). Only approximately 7% of published works are provided in accessible formats for print-disabled individuals. In developing countries, this percentage drops even lower, to less than 1% (Coates et al., 2018, p.10).

Following the adoption of the Marrakesh Treaty in 2013, the European Parliament enacted two significant legislative measures. The first is Directive (EU) 2017/1564 of the European Parliament and of the Council of 13 September 2017, which addresses certain permitted uses of copyrighted works and related subject matter for the benefit of persons who are blind, visually impaired or otherwise print-disabled. This directive also amends Directive 2001/29 on the harmonisation of certain aspects of copyright and related rights in the information society.

The second legislative act is Regulation (EU) 2017/1563 of the European Parliament and of the Council of 13 September 2017, which focuses on the cross-border exchange between the European Union and third countries of accessible format copies of certain works and related subject matter protected by copyright and related rights for the benefit of persons who are blind, visually impaired, or otherwise print-disabled.

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Both the Directive and Regulation for the implementation of the Marrakesh Treaty into EU law were published in the Official Journal on 20 September 2017 and entered into application on 12 October 2018.

Additional regulations aimed at increasing the accessibility of works for print-disabled users include:

- Directive on Copyright in the Digital Single Market (Directive 2019/790): This directive, adopted in 2019, updates EU copyright rules to better align with the digital age. It incorporates provisions related to the accessibility of works for persons with disabilities.
- EU Web Accessibility Directive (Directive (EU) 2016/2102): While not specifically linked to copyright, this directive mandates that public sector websites and mobile applications must be accessible to all users, including those with disabilities. Its goal is to ensure that individuals with disabilities can fully engage in the digital society and access online information and services. Interestingly, WebAim's annual research on the top million websites, according to Tranco ranking, still shows dissatisfactory results in website accessibility. The latest report from 2024 even indicates an increase in automatically detected errors per page compared to 2023. The majority of these issues stem from low-contrast text, missing alternative text, absent form labels, empty links, empty buttons, and lacking document language specification (WebAIM, 2024b). According to WebAIM's Screen User Survey #10 (WebAIM, 2024a) conducted between 2023 and 2024, 34.6% of screen reader users believe that web content has become more accessible, while 46.8% of users feel that web content accessibility has remained unchanged over the past year. A staggering 85.9% of users believe that the greatest impact on accessibility would occur if websites were more accessible. The same survey reveals that screen reader users seldom contact site owners, with 44.3% reporting that they do so not very often, 24.8% somewhat often, only 9.2% very often and 21.7% never. Such findings demonstrate that this issue persists as a significant challenge, not only in Europe but also World wide.
- European Accessibility Act (EAA) (Directive EU) 2019/882): Adopted in 2019, this act aims to enhance the accessibility of products and services throughout the European Union, encompassing both physical and digital content and technologies. Although its primary focuses on physical products and services, it also addresses the born-accessible digital content, specifically published e-books, which can provide benefits to blind and partially sighted users.

"These guidelines establish criteria to ensure that all web content is accessible to everyone, including individuals who are blind or partially sighted."

These regulations and directives, in conjunction with Directive 2017/1564, constitute a significant aspect of the comprehensive legal framework within the European Union designed to enhance access to printed materials for individuals with print disabilities. They aim to ensure equal access to cultural, educational, and digital resources for this population.

Libraries can enhance the discoverability of their accessible format works for other libraries through metadata in catalogue records and by sharing information with other institutions. It is essential that accessible book services operate on a non-profit basis.

It is worth mentioning the Web Content Accessibility Guidelines (WCAG) (Campbell et al., 2023)[9] initially a recommendation by the World Wide Web Consortium (W3C).[10]

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These guidelines establish criteria to ensure that all web content is accessible to everyone, including individuals who are blind or partially sighted. The guidelines are outlined in both the EU Web Accessibility and EAA directives, and adherence to these guidelines can significantly enhance access to e-books for the blind and partially sighted, as well as for users of mobile devices.

3. Methodology

In our 2020 research, our aim was to address the following questions:

- Q1: How do sighted individuals and blind or partially sighted users typically access e-books?
- Q2: What are the common reading practices of these two communities when using e-books?
- Q3: What are the specific needs of blind and partially sighted communities regarding e-books?
- Q4: How does file format affect the reading experience of both communities?
- Q5: Which mobile devices are predominantly used by both communities of e-book readers?

Two surveys were conducted from 20 April to 30 June 2020. The objective was to gain insights into the experiences of e-book users without visual impairments and to understand the needs of blind and partially sighted e-book users.

The survey questionnaires, created using 1KA,[11] comprised 20 questions (2 open-ended and 18 closed-ended). In two questions we unitized a Likert scale. There were slight variations between the questionnaire for users of mobile devices and the questionnaire for blind and partially sighted users. The text was initially prepared in English and then translated into the national languages of the 15 partner libraries participating in the EODOPEN project (including university, national, and special libraries). These libraries were responsible for distributing the questionnaires to their users. If a partner library did not serve these communities, they were instructed to contact specialized libraries for the blind and partially sighted in their respective countries.

The objective of both surveys was to obtain an overview of the positive and negative aspects of e-book features, usage on various mobile devices, and the most frequently used e-book file formats.

For data analysis, PSPP was utilised. PSPP is a statistical analysis tool developed as a free, open-source alternative to SPSS. It facilitated the analysis of different correlations within the data.

4. Research results

The questionnaires were tailored to two distinct user groups: those accessing e-books via mobile devices and blind or partially sighted e-book readers. They inquired about the methods of accessing and utilising e-books within each community, as well as the predominant technologies (devices, software, and file formats) utilised by them. As previously mentioned, we customized the questionnaire to accommodate the specific needs and experiences of these two distinct user communities.

When analysing the responses to two questions with Likert scale, we combined the answers „always" and „usually" and presented them as a combined result. Similar case was with „sometimes" and „never".

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4.1. Demographic data

In the survey of mobile device users, we collected data from 2,314 respondents. However, in our analysis, we considered 1,718 responses from participants who answered at least 80% of the questions. Responses categorized as „Other" were not considered for analysis. The majority of respondents fell within the age range of 20 to 29 (682 respondents, accounting for 39.7%), indicating that a significant portion of the respondents were students. This demographic was followed by library professionals (323 respondents, 18.8%) and academics (teachers, professors, etc.) (136 respondents, 11%). Lower number of respondents declared to be affiliated with local government (136, 7.92%), unemployed individuals (28, 1.63%), and retired (43, 2.5%). The category „Other" was chosen by 260 respondents (15.13%), who are presumed to be professionals from various fields not covered by the predefined categories (Table 1).

Age of respondents	Frequency	Student	Affiliates with local government	Creative industry	Academics	Library professionals	Unemployed	Retired	Other
Up to 19	48 (2.79%)	40 (6.06%)	1 (0.74%)	0	0	0	1 (3.57%)	0	6 (2.4%)
20–29 years	682 (39.70%)	556 (84.24%)	15 (11.03%)	11 (13.92%)	33 (17.46%)	35 (10.84%)	5 (17.86%)	0	27 (10.8%)
30–39 years	306 (17.81%)	42 (6.36%)	28 (20.59%)	24 (30.38%)	50 (26.46%)	77 (23.84%)	8 (28.57%)	0	76 (30.4%)
40–49 years	330 (19.21%)	16 (2.42%)	50 (36.76%)	22 (27.85%)	56 (29.63%)	108 (33.44%)	8 (28.57%)	1 (2.33%)	68 (27.2%)
50–59 years	235 (13.68%)	5 (0.76%)	31 (22.79%)	18 (22.78%)	36 (19.05%)	83 (25.7%)	5 (17.86%)	4 (9.3%)	52 (20.8%)
More than 60 years	109 (6.34%)	1 (0.15%)	11 (8.09%)	3 (3.8)	19 (7.41%)	20 (6.19%)	1 (3.57%)	38 (88.37%)	21 (8.4%)
Not defined	8 (0.005%)								10 (0.006%)
Total:	1718 (100%)	660 (38.42%)	136 (7.92%)	79 (4.6%)	189 (11%)	323 (18.8%)	28 (1.63%)	43 (2.5%)	260 (15.13%)

Table 1: Demographic data on users of mobile devices: Overview of survey respondents by age and by status

From the population of blind and partially sighted users, we collected data from 736 respondents. However, we considered 525 responses from participants who answered at least 50% of the questions. The majority of respondents were aged above 40 years old (337 respondents, 64.2%), followed by 72 respondents (13.7%) aged 30 to 39, 72 respondents (13.7%) aged 20 to 29, and 18 respondents (3.4%) aged 19 or younger (Table 2). Among the respondents, most (179, 33.1%) were retired, with 54 (10.3%) being students and 43 (8.2%) affiliated with local government institutions. Regarding the level of sight, there were 184 respondents (35%) classified as blind, 148 (28.2%) as almost blind, and 149 (28.4%) as partially sighted.

When comparing the age of respondents from this second survey with their status as persons with special needs, we found a consistent number of blind individuals across age groups, indicating that blindness is not strongly correlated with age. However, there was an increase in almost completely blind and partially sighted respondents with higher age.

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Age of respondents	Frequency	Blind	Almost blind	Partially sighted	No response
Up to 19	18 (3.4 %)	8 (4.35%)	5 (3.4%)	5 (3.4%)	0
20–29 years	72 (13.7%)	31 (16.8%)	21 (14.2%)	16 (10.7%)	4 (9.1%)
30–39 years	72 (13.7%)	32 (17.4%)	16 (10.8%)	22 (14.8%)	2 (4.5%)
40–49 years	90 (17.1%)	34 (18.5%)	27 (18.2%)	21 (14.1%)	8 (18.2%)
50–59 years	97 (18.5%)	32 (17.4%)	28 (18.9%)	34 (22.8%)	3 (6.1%)
More than 60 years	150 (28.6%)	45 (24.5%)	49 (33.1%)	50 (33.6%)	6 (13.6%)
Not defined	26 (5.0%)	2 (1.1%)	2 (1.4%)	1 (0.7%)	21 (47.7%)
Total:	525 (100%)	184 (35.0%)	148 (28.2%)	149 (28.4%)	44 (8.4%)

Table 2: Demographic data on blind and partially sighted users: Overview of survey respondents by age and level of sight

4.2. Access and e-book usage

E-book users who use mobile devices typically access them through **digital libraries** (938, 54.59% of all respondents). This group comprises 65.3% of respondents who identified as students (431, 25.09% of all respondents) or aged up to 29 years (457, 26.6% of all respondents), as well as 124 respondents who are academics (7.22% of all respondents). Additionally, 153 respondents (8.91% of all respondents) are library professionals.

A significant portion of respondents in this group (698, 40.62% of all respondents) borrow or download e-books from libraries. Illegal or pirate sources are of interest to 26.48% of respondents (455), primarily among younger populations across all age groups up to 39 years.

"A significant portion of respondents in this group (698, 40.62% of all respondents) borrow or download e-books from libraries."

Furthermore, 43.71% of respondents in this group (751) purchase e-books online through commercial services. The majority of these purchasers fall within the age groups of 20-29 years (230, 13.39% of all respondents), 30-39 years (167, 9.72% of all respondents), and 40-49 years (165, 9.6% of all respondents). Among these respondents, 216 are students (12.57% of all respondents), 111 are library professionals (6.46% of all respondents), and 99 are academics (5.76% of all respondents). Additionally, 17 respondents categorized as unemployed (0.99% of all respondents), 41 in the creative industry (2.39% of all respondents), and 47 in local government organisations (2.74% of all respondents) also prefer to purchase e-books through commercial services.

Blind and partially sighted users prefer to borrow or download e-books in the library (305, 58.1% of all respondents) and to access them through the digital library (227, 43.24% of all respondents). Respondents also purchase e-books (182, 34.67% of all respondents) and use illegal/pirate sources (42, 8% of all respondents). We compared way of access with most important functions for them and haven't found any

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correlation, way of access doesn't influence the functions they use. We also compared way of access with attention to e-book format and as well haven't found significant differences. The percentages of the collected data are shown in Fig. 1.

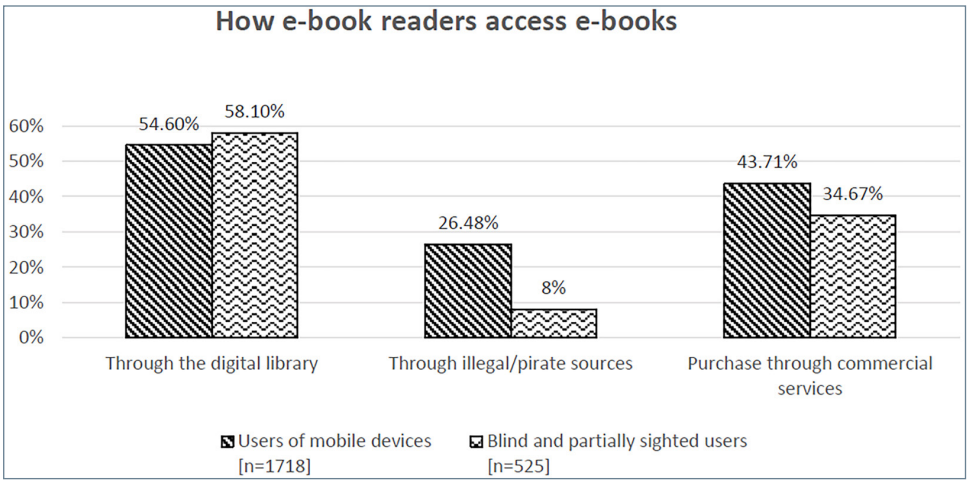

Fig. 1: How e-book readers access e-books – comparison in % between users of mobile devices and blind and partially sighted communities

The majority of respondents who use mobile devices (1478, 86.03% of all respondents) prefer to **download e-books and read them offline**. A significant number of respondents (783, 45.58% of all respondents) read them online. There is no significant dependence on age or status in this preference.

Most blind and partially sighted respondents prefer to download e-books and read them offline (445, 84.76% of all respondents), followed by reading them online (141, 26.86% of all respondents). Other methods of using e-books are rarely utilised.

More than half of the respondents who use mobile devices (983, 57.22%) indicated that they **read the e-book from start to end**. Approximately a third of the respondents (652, 37.95% of all respondents) prefer to read only the chapters or pages they are interested in, or they search for specific information they need (568, 23.06% of all respondents). These behaviours are particularly prevalent among students, as indicated by the age groups represented. The majority of respondents in this group (1029, 59% of all respondents) reported that their **reading time typically lasts more than 30 minutes**.

When it comes to navigating e-books, most respondents who use mobile devices (1020, 59.37% of all respondents) **search for the table of contents** in the e-book. They sometimes or never search for list of figures (1304, 75.94% of all respondents), index (1069, 62.28% of all respondents) or references (991, 57.7% of all respondents). However, there is no significant correlation observed with age group or status.

Blind and partially sighted respondents predominantly **read e-books from start to end** (387, 73.72% always and usually), with fewer opting to read only the first few pages (70, 13.33% always and usually). Other reading practices are infrequently employed or not at all. The majority of respondents reported that their **reading time typically exceeds 30 minutes** (395, 75.24%). We compared reading times across different devices but found no significant differences.

When navigating e-books, most blind and partially sighted respondents **search for the table of contents** (282, 53.72% always and usually), followed by the abstract (110, 20.95% always and usually), and references (88, 16.76% always and usually).

"More than half of the respondents who use mobile devices (983, 57.22%) indicated that they read the e-book from start to end."

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There was no observed correlation between the status as a person with special needs and e-book usage patterns. Fig. 2 illustrates a comparison of practices between both communities.

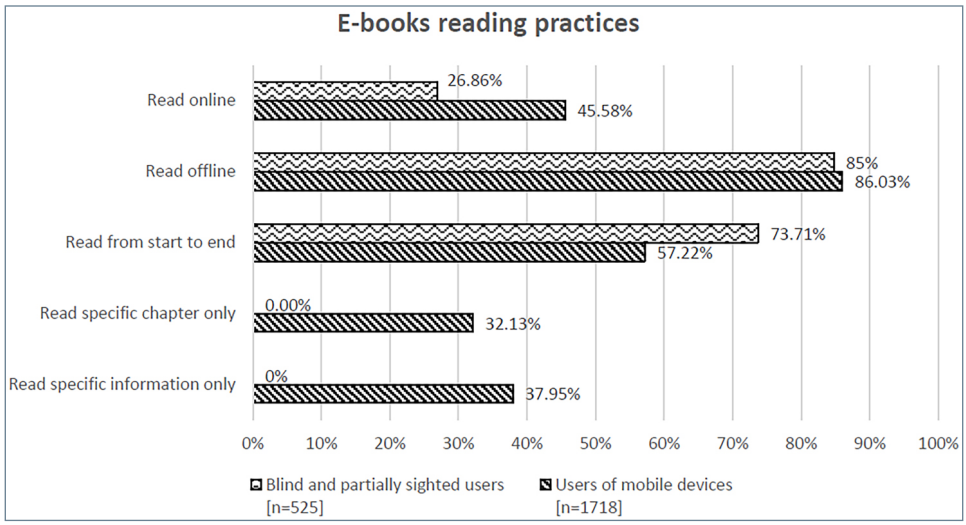

Fig. 2: E-books reading practices – comparison in % between users of mobile devices and blind and partially sighted communities

4.3. Expected e-book features by respondents

75.73% (1301) of all respondents who use mobile devices consider the **downloading** functionality very important. Specifically, it is valued highly by 81.82% of respondents aged 20-29 (558, 32.48% of all respondents), and by 80.91% of respondents who are student (534, 31.08% of all respondents), 76.72% of academics (145, 8.44% of all respondents) and 83.72% of retired (36, 2.1% of all respondents). Notably, a significant portion of library professionals (71.83%) also deem downloading very important (232, 13.5% of all respondents).

The second most valued feature among respondents in this group is the **full-text search** functionality (1098, 63.91%). This is particularly true for 74.93% of individuals within the 20-29 age bracket (511, 29.74% of all respondents), and for 75% of students (495, 28.81% of all respondents), as well as 73.02% of academics (138, 8.03% of all respondents), and 59.13% of library professionals (191, 11.12% of all respondents).

Approximately 40% of respondents in this group assign high importance to **browsing and zooming** (790, 45.98%), as well as pagination (668, 38.88%). Personalization is valued highly by 33.76% (580) of respondents, especially by 24.83% of students (144, 8.38% of all respondents), 36.53% of library professionals (118, 6.87% of all respondents), and 50% of unemployed respondents (14, 0.81% of all respondents), 55.81% of retirees (24, 1.4% of all respondents), and 48.8% of respondents categorized as "Other" (122, 7.1% of all respondents).

Blind and partially sighted individuals consider **downloading** functionality as very important or important (83.04%), followed by full text search (62.09%), **browsing and zooming** (48.19%), bookmarks (48%), copy & paste (42.85%), and pagination (46.47%).

Downloading, full-text search, browsing and zooming, and pagination emerge as the most important features for both communities (Fig. 3).

"75.73% (1301) of all respondents who use mobile devices consider the downloading functionality very important."

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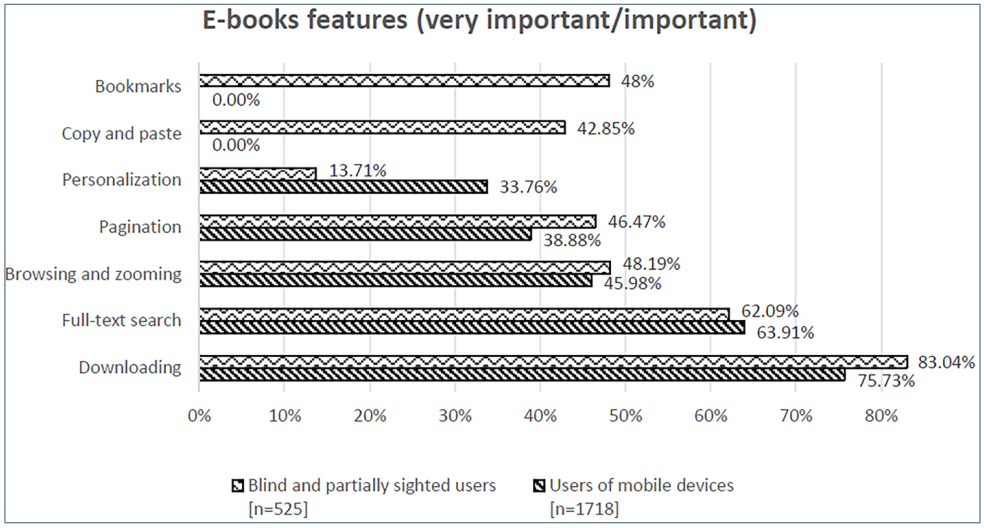

Fig. 3: Most important features for e-book users – comparison in % between users of mobile devices and blind and partially sighted communities

4.4. Usual problems with e-books

49.01% (842) of respondents using mobile devices encountered issues with full-text restrictions (specifically, the inability to copy-paste). This limitation is particularly significant for 64.58% of respondents using mobile devices, among whom there are 31 individuals (1.8% of all respondents) aged up to 19, 406 respondents (59.53% of all respondents) in the 20–29 age group, 417 students (63.18% of all respondents), 138 library professionals (42.72% of all respondents), and 100 academics (52.91% of all respondents).

48.49% (833) of respondents in this group experienced issues with page numbering, primarily due to discrepancies with page numbers in printed books. This concern was noted by 59.85% of students (395, 22.99% of all respondents), 41.8% of library professionals (135, 7.86% of all respondents), and 53.97% of academics (102, 5.94% of all respondents).

For 46.39% (797) of respondents in this group the e-book navigation system was either unclear or non-functional. Of lesser importance were functionalities related to responsive design (623, 36.26%) and the ability to export notes/comments/highlights (537, 31.26%). The latter was particularly valued by the student population (43.75%) of the category of respondents aged up to 19 (21, 1.22% of all respondents) and 35.34% of those aged 20-29 years (241, 14.03% of all respondents), as well as by 37.73% of students (249, 14.49% of all respondents), 26.63% of library professionals (86, 5.01% of all respondents), and 52.91% of academics (71, 4.13% of all respondents). Print restriction posed a problem for 26.14% (449) of respondents.

Blind and partially sighted respondents primarily encountered difficulties with using specific software for reading (275, 52.38%), unclear or malfunctioning e-book navigation system (226, 43.05%), full text restriction (as the inability to copy-paste) (181, 34.48%), unclear e-book's tool function settings (168, 32%) and issues with the page numbering (157, 29.9%).

When comparing the experiences of individuals with special needs with this question, we observed minor differences. All participants highlighted problems with the navigation system and the disabled copy-paste option. Additionally, blind individuals noted issues with page numbering (82, 15.62% of all respondents), while partially sighted individuals also mentioned the unavailability of

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additional features (58, 11.05% of all respondents) and the lack of flexible formatting for screen size (50, 9.52% of all respondents).

Fig. 4 illustrates the most commonly reported problems by users of mobile devices as well as blind and partially sighted e-book users.

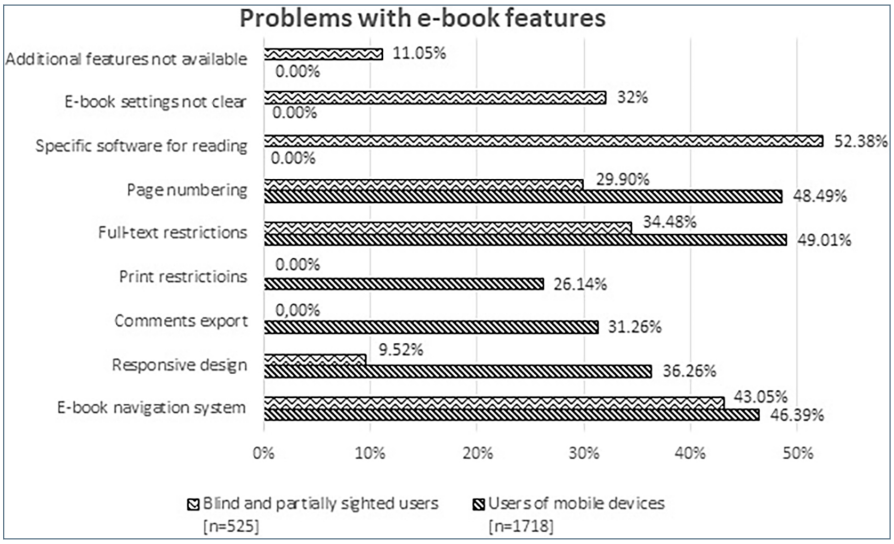

Fig. 4: Problems with e-book features – comparison in % between users of mobile devices and blind and partially sighted communities

4.5. E-book software and file formats

41.97% (721) of respondents using mobile devices deem the specific software for reading important, while 66.53% (1143) prioritize the text format. Additionally, 18.74% (322) of respondents utilise software to convert the current format into a more suitable one for reading, with no discernible correlation with age or status.

Regarding the rating of e-book file formats in this group, PDF was rated as excellent and above average by 786 respondents (45.75% of all respondents). Among respondents aged 20-29, 41.5% rated PDF as excellent (283, 16.47% of all respondents) or above average (76, 4.42% of all respondents). In contrast, a number of respondents considered EPUB as excellent or above average (659, 38.36% of all respondents), with a preference among those aged 20-29 (144, 8.38% of all respondents), 40-49 (100, 5.82% of all respondents), and 30-39 (99, 5.76% of all respondents). Among respondents categorized by status, 24.15% of library professionals (78, 4.54% of all respondents), 30.16% of academics (57, 3.32% of all respondents), and 17.88% of students (118, 6.87% of all respondents) rated EPUB as excellent. Other formats (HTML, TXT, RTF) received ratings ranging from 1% to 4%.

These results were unexpected, as the EPUB file format offers more potential for different types of access compared to PDF. The discrepancy may be attributed to the greater popularity of PDF and a lack of familiarity with EPUB among users.

"These results were unexpected, as the EPUB file format offers more potential for different types of access compared to PDF. The discrepancy may be attributed to the greater popularity of PDF and a lack of familiarity with EPUB among users."

The text-to-speech option when reading e-books is utilised by only 1.75% (30) of respondents who use mobile devices.

More than half of the blind and partially sighted respondents pay attention to text format (285, 54.29%), especially those who use screen reading software in their native language (175, 33.33%). Attention to format is particularly important to those who borrow/download e-books from the library (162, 30.86%).

Blind and partially sighted rated e-book file formats differently. PDF was rated as excellent and above average by 26.1% of respondents, TXT by 22.1%, EPUB 20%, HTML as 18.1% and RTF as 17%. When comparing the preferences of individuals

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with special needs, differences emerged. Among blind, the excellent and above average file format was rated TXT (49, 26.6%), followed by RTF (45, 24.5%), HTML (41, 22.3%), PDF (32, 17.4%) and EPUB (26, 14.1%). Among almost completely blind the rating was best for PDF (42, 28.4%), followed by TXT (35, 23.6%), EPUB (27, 18.2%), RTF (25, 16.9%) and HTML (22, 14.9%). Lastly, among partially sighted the rating was best for PDF (49, 32.9%), followed by EPUB (42, 28.2%), TXT (26, 17.4%), HTML (27, 18.1%) and RTF (15, 10.1%).

Other formats that respondents frequently mentioned and evaluated were DOC or DOCX (17, 2.86%), audio formats (MP3 and DAISY) (7, 1.14%), and AZW or MOBI format (7, 1.14%).

In comparing the use of assistive technologies with file formats (average scores), it was observed that those who use a braille display with a keyboard prefer TXT and RTF formats, users of magnifier software prefer PDF and EPUB formats, and users of screen reading software in their native language prefer TXT, EPUB, and RTF, similar to those who use screen reading software in other languages.

180 (34.29%) blind and partially sighted respondents reported using software to convert the current format to a more suitable one for reading. Conversion is most often performed by blind individuals (90, 17.14%). The conversion process is most commonly utilised on notebooks (130, 24.76%) and smartphones (106, 20.19%).

Blind and partially sighted individuals most frequently mentioned the following software for file format conversion (mentioned at least 5 times): Abbyy FineReader (33, 6.29%), Balabolka (26, 4.95%), Calibre (17, 3.24%), Voice Dream Reader (12, 2.29%), MS Word (11, 2.1%), Robobraille (5, 0.95%), and Adobe Acrobat (5, 0.95%). Additionally, approximately 30 other apps, software, and online converters were mentioned.

They most commonly convert files into the following formats: TXT (49, 9.33%), doc/docx/word (48, 9.14%), PDF (23, 4.38%), mp3/DAISY/audio/Balabolka (22, 4.19%), EPUB (20, 3.81%), and RTF (13, 2.48%). Other formats mentioned, but selected few times, include HTML, mobi/azw, braille/BRL, and UTF8.

We believe that the choice of format depends on the extent to which the user utilises their remaining sight. Individuals with limited sight prioritize accessing full text and using assistive technologies over visual elements. Conversely, those with higher levels of sight may prefer adjustments that allow them to use their vision alongside assistive technologies. Thus, it's important to accommodate both groups of users in e-book accessibility efforts.

"We believe that the choice of format depends on the extent to which the user utilises their remaining sight."

4.6. Devices for reading e-books

We were surprised to find that half of the respondents using mobile devices prefer smartphones (939, 54.66% of all respondents) or notebooks (944, 54.95% of all respondents) as devices for reading e-books. This preference was further confirmed by correlating with their status. Among students, 68.79% prefer notebooks (454, 26.43% of all respondents), while 60.76% prefer smartphones (401, 23.34% of all respondents). Similarly, among academics, 68.25% prefer notebooks (129, 7.51% of all respondents), and 49.74% opt for smartphones (94, 5.47% of all respondents). Among library professionals, 59.75% also opt for these two devices preferring smartphones (193, 11.23% of all respondents) and 46.44% choosing notebooks (150, 8.73% of all respondents).

Tablets (37.89%) and e-readers (41.79%) are less commonly used by this group of respondents, primarily by 53.16% of respondents in the creative industry category (42, 2.44% of all respondents), 60.71% of unemployed individuals (17, 0.99% of all respondents), and 55.81% of retirees (24, 1.4% of all respondents). A higher percentage

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(72.92%) of respondents aged up to 19 prefer smartphones (35, 2.04% of all respondents) and notebooks (60.42% (29, 1.69% of all respondents)), as do those aged 20-29 (smartphone 60.12% (271, 15.77% of all respondents) and notebook 66.28% (452, 26.32% of all respondents)). Given the age groups, we speculate that students typically use notebooks for study, which may account for these results. Despite previous results, respondents consider e-readers as the most suitable for reading e-books (945, 49.19%), followed by tablets (415, 24.16%) and notebooks (344, 20.02%).

Blind and partially sighted individuals primarily use notebooks for reading e-books (306, 58.29%), followed by smartphones (268, 51.05%). Less commonly used devices include tablets (136, 25.9%) and e-readers (104, 19.81%). Notably, the device they use is also the one they find most suitable for their needs.

4.7. Assistive technologies for the blind and partially sighted users

Blind and partially sighted respondents primarily utilise **screen reader software in their native language** (327, 62.29%), followed slightly behind by those who use screen reader software in other language (124, 23.62%), braille display with a keyboard (107, 20.38%) and magnifier software (103, 19.62%).

When comparing the status of individuals with special needs, we obtained 307 responses from blind individuals, 192 from almost completely blind individuals, and 144 from partially sighted individuals. Blind individuals predominantly (49.19%) use screen reader software in their native language (151, 28.76% of all respondents), followed by 28.34% braille display with a keyboard (87, 16.57% of all respondents), and screen reader software 21.82% in another language (67, 12.76% of all respondents). As expected, they rarely (0.65%) use magnifier software (2, 0.38% of all respondents). Almost completely blind individuals most frequently (52.08%) use screen reader software in their native language (100, 19.05% of all respondents) and also 20.83% utilise magnifier software (40, 7.62% of all respondents). They less frequently (19.27%) use screen reader software in another language (37, 7.05% of all respondents) and 7.81% braille display with a keyboard (15, 2.86% of all respondents). Partially sighted individuals primarily (45.83%) use screen reader software in their native language (66, 12.57% of all respondents) and 40.28% magnifier software (58, 11.05% of all respondents). They less frequently (11, 0.11%) use screen reader software in another language (16, 3.05% of all respondents) and almost never (2.78%) use a braille display with a keyboard (4, 0.76% of all respondents).

Additionally, when comparing types of assistive technologies with devices, we noticed that screen reading software in the native language is most commonly used on all mobile devices (notebook 217, 41.33%; phone 202, 38.47%; tablet 83, 15.81%; and e-reader 42, 8%). Braille display with a keyboard is most often utilised on notebooks (83, 15.81% of all respondents), closely followed by smartphones (69, 13.14% of all respondents).

5. Discussion

The survey results offer valuable insights into the varied preferences and behaviours of e-book users, encompassing both users of mobile devices and those with special needs.

Regarding demographic breakdown, e-book users using mobile devices are predominantly in the 20-29 age bracket (39.7%), with a substantial representation from student communities (38.42%). Conversely, blind and partially sighted e-book readers skew older, with 64.2% aged 40 or above, notably including retirees (34.1%). This demographic contrast underscores the significance of addressing digital literacy

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and mobile device usage among older age cohorts. Revisiting the initial research questions, the gathered data has provided meaningful answers.

In terms of **access mode (Q1),** digital libraries emerge as the preferred choice for users of mobile devices and visually impaired respondents, comprising 30% of users. A significant portion, 40.62% users of mobile devices and 40.3% of blind or partially sighted users, prefer borrowing or downloading e-books from libraries.

A notable proportion of users using mobile devices (43.71%) and blind and partially sighted respondents (34.67%) opt to purchase e-books through commercial services, particularly among students, library professionals, and academics.

Concerningly, 26.48% of respondents using mobile devices admit to accessing e-books from illegal or pirate sources, a trend more prevalent among the younger population, especially those aged up to 39. Among the blind and partially sighted users there are 8% of such cases.

In terms of **reading habits (Q2)** and accommodating the **special needs of both user groups (Q3),** a majority of respondents (86.03% of users using mobile devices and 72.5% of blind and partially sighted users) prefer downloading e-books for offline reading sessions lasting over 30 minutes, with 34.58% of first group of respondents and 73.8% of blind and partially sighted respondents reading from beginning to end. Notably, most users using mobile devices fall into this category are aged up to 29.

We discovered that 75.2% of respondents using mobile devices engage in reading sessions exceeding 30 minutes and are not influenced by the device they use.

Significantly, approximately 40% of users using mobile devices and 53.7% of blind and partially sighted respondents consistently or frequently search for the table of contents in e-books, demonstrating a preference for structured navigation.

Key features considered important by users of mobile devices include downloading capability, full-text search (63.91%), browsing and zooming (45.98%). PDF emerges as the preferred file format (45.76%), followed by EPUB (38.36%), accommodating diverse user preferences.

Among those classified as having special needs, all three groups highly value the downloading functionality. Blind users additionally prioritize full-text search, copy & paste, and pagination. Nearly completely blind individuals find full-text search, browsing and zooming, bookmarks, and copy & paste crucial. Partially sighted users emphasize browsing and zooming, interface personalization, and full-text search.

Common issues reported by respondents using mobile devices include problems with full-text restrictions (49.01%), difficulty with page numbering (48.49%), and unclear navigation systems (46.39%). Additionally, concerns were raised about responsive design (6.26%), comments/notes export (31.26%), and print restrictions (26.14%).

The usual problems with e-books reported by blind and partially sighted respondents include the need for specific reading software (18%), unclear or malfunctioning navigation systems (14.8%), full-text restrictions such as unavailable copy-paste functions (11.8%), unclear e-book tool function settings (11%), and issues with page numbering (10.3%).

All three groups classified as persons with special needs encounter difficulties with navigation systems and encounter issues with disabled copy-paste functionality. Additionally, blind individuals highlighted problems with page numbering, while partially sighted individuals also noted the lack of flexibility in screen size formatting and the absence of additional features.

"We discovered that 75.2% of respondents using mobile devices engage in reading sessions exceeding 30 minutes and are not influenced by the device they use."

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"These findings emphasize the necessity of accommodating diverse user needs, ensuring accessibility, and addressing challenges to improve the e-book reading experience for all individuals, regardless of their abilities."

When examining **how file formats influence the reading experience of both communities (Q4),** we discovered that 66.53% of respondents using mobile devices pay attention to text formats, with 41.97% considering specific software for reading important. Only 18.74% of respondents utilise software to convert the current format into a more suitable one. Among those who typically download e-books for offline reading, 58.56% pay attention to text formats. The most preferred file format for e-books is PDF (45.76%), followed by EPUB (38.36%). HTML, TXT, and RTF were selected by 1%-4% of respondents.

For 54.3% of blind and partially sighted respondents, text format is a consideration, particularly among those who use screen reading software in their native language (33.3%). Format attention is especially important for those who borrow or download e-books from libraries (30.9%). The most preferred file formats (rated excellent or above average) for e-books are: PDF (26.1%), TXT (22.1%), EPUB (20%), online HTML (18.1%), and RTF (16.9%). On average, the popularity of formats is as follows: EPUB, PDF, and TXT, followed by RTF and online HTML.

Blind individuals believe that TXT and RTF are the most suitable formats, while almost completely blind respondents rated TXT and EPUB as best, and partially sighted individuals rated EPUB and PDF as best.

Preferences vary among users of different assistive technologies: those using braille displays with keyboards prefer TXT and RTF formats, while users of magnifier software prefer PDF and EPUB formats. Users of screen reading software prefer TXT, EPUB, and RTF formats, with DOC and DOCX being additional mentioned formats.

A notable 34.3% of blind and partially sighted respondents use software for converting e-book formats, with Abbyy FineReader, Balabolka, and Calibre being among the most commonly used tools. The most frequently converted formats include TXT, DOC/DOCX/Word, PDF, MP3/DAISY/audio/Balabolka, EPUB, and RTF. We believe that the choice of format depends on how much the user uses his remaining sight and their preferences regarding the actual use of visual elements – considering both groups who use or don't use them.

Regarding the primary **mobile devices used by both communities of e-book readers (Q5),** respondents using mobile devices predominantly prefer notebooks (54.95%) and smartphones (54.66%) for extended reading sessions. However, when queried about their preferred device for e-book reading, smartphone users often expressed a preference for e-readers (24.1%). Tablets and e-readers are utilised by roughly 40% of respondents, primarily from categories of students, library professionals, or academics. E-reader and tablet users tend to stick with their chosen devices. The use of the text-to-speech option is relatively rare, employed by only 1.75% of respondents.

For blind and partially sighted users, the most preferred devices for e-book reading are notebooks (58.3%) and smartphones (51.1%). Tablets are utilised by a minority (25.9%), with e-readers being the least popular choice (19.8%). This suggests potential compatibility issues with assistive technologies.

Among blind and partially sighted users, screen reader software in their native language (49.5%) and magnifier software (15.6%) are commonly used tools. Additionally, a significant portion of visually impaired users (16.2%) prefer braille displays with keyboards, particularly those who value tactile feedback. Blind users predominantly rely on screen reader software in their native language (49.2%) and braille displays with keyboards (28.3%), with minimal usage of magnifier software (0.7%). Almost completely blind individuals primarily utilise screen reader software in their native language (52.1%) and magnifier software

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(20.8%), with lesser reliance on screen reader software in other languages (19.3%) and braille displays with keyboards (7.8%). Partially sighted individuals most commonly utilise screen reader software in their native language (45.8%) and magnifier software (40.3%), with lower usage of screen reader software in other languages (11.1%) and rare use of braille displays with keyboards (2.8%).

Screen reading software in the native language is predominantly used across all mobile devices (notebook 41.3%, phone 38.5%, tablet 15.8%, and e-reader 8%). Braille displays with keyboards are most frequently utilised on notebooks (15.8%), closely followed by smartphones (13.1%).

These findings emphasize the necessity of accommodating diverse user needs, ensuring accessibility, and addressing challenges to improve the e-book reading experience for all individuals, regardless of their abilities.

6. Conclusion

In conclusion, the survey findings provide a comprehensive understanding of the preferences, behaviours, and challenges encountered by e-book readers, encompassing both individuals using mobile devices and those with special needs.

The demographic breakdown reveals notable differences in age distribution between both groups of respondents, highlighting the importance of addressing digital literacy and mobile device usage among older age groups. Due to diversity of users, thinking about accessibility for all different groups is the best choice when developing services for library users.

Regarding access modes, digital libraries emerge as the preferred choice for both groups of respondents, with a significant proportion opting to borrow or download e-books. However, concerns arise from a considerable percentage accessing e-books from illegal sources, particularly among younger users of mobile devices. Making digital libraries as websites accessible according to Directive (EU) 2016/2102 and Directive 2019/882 is thus important as way of access is part of accessibility, not only the accessibility of material, offered on the digital libraries.

In terms of reading habits and accommodating special needs, there is a clear preference for offline reading sessions lasting over 30 minutes, with structured navigation being crucial for many users. Key features such as downloading capability, full-text search, and flexible formatting are highly valued, especially among those with special needs.

File format preferences vary among users, with PDF being the most preferred, followed by EPUB. Blind individuals prioritize formats without visual elements (TXT and RTF) and those that are compatible with screen reading software and braille displays. Partially sighted users emphasize formats conducive to magnifier software and personalized interfaces.

Mobile device preferences also vary, with notebooks and smartphones being popular choices for both groups of respondents. However, compatibility issues with assistive technologies may affect the popularity of e-readers among the blind and partially sighted.

Overall, these findings underscore the importance of catering to diverse user needs, ensuring accessibility, and addressing challenges to enhance the e-book reading experience for all individuals, irrespective of their abilities. Efforts to improve digital literacy, promote legal access to e-books, and develop inclusive design features will contribute to a more equitable and enjoyable reading experience for everyone.

Footnote

[1] Digitisation on Demand (DoD), eTEN European program, from 1 October 2006 to 30 June 2008 and eBooks on Demand (EOD), Creative Europe, from 1 May 2009 to 30 April 2014).

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