Electronic Educational Books for Blind Students

50.1 Introduction

In the past, students with disabilities used to be segregated into special schools or classrooms, populated only by children sharing the same disability. This practice had a negative impact on the ability and opportunities of these students for inclusion in society. As a result, presently many countries follow a more open approach called inclusive education (Clough and Corbett, 2000), where students with disabilities participate in the mainstream classrooms. This approach provides better opportunities for inclusion to those students, but also raises new challenges to the educational system, as students with disabilities need to access the same educational material as the rest of the students.

Access to educational material, as to any other type of printed material, constitutes a major challenge for blind people. The traditional method employed to overcome this problem is to transcribe school textbooks in Braille format, using Braille typewriters and embossers (i.e., printers), or to record them in the form of audiotapes and CDs. Both of these approaches suffer from numerous drawbacks (Petrie et al., 1997), which are mainly due to their physical instantiation, as well as to the limited interaction capabilities that they can offer. Furthermore, the two approaches work complementarily, since depending on the abilities, knowledge, and preferences of the learner, as well as the current context of use, only one or both of them should be employed. Thus, the availability of content in just one form may once more result in lack of accessibility.

Nowadays, the existence of educational content in electronic format has the potential, on the one hand, to overcome the aforementioned limitations, while, on the other hand, to take advantage of the best qualities of both approaches, since electronic documents can be rendered in both audio and tactile form, but, most important, they can be augmented with numerous, added-value interaction capabilities.

In this context, this chapter introduces the concept of electronic books and the way that they can be used to provide accessible educational textbooks to blind students. Furthermore, it presents a novel software platform for developing and interacting with multimodal interactive electronic textbooks that provide a dual user interface (Savidis and Stephanidis, 1995), that is, an interface concurrently accessible by visually impaired and sighted persons. The platform, named Starlight, comprises two subsystems: (1) the Reader, facilitating the authoring of electronic textbooks, encompassing various categories of interactive exercises (Q&A, multiple choice, fill in the blanks, etc.); and (2) the Reader, enabling multimodal interaction with the created electronic textbooks, supporting various features like searching, bookmarking, replay of sentences or paragraphs, user annotations and comments, activity recording, and context-sensitive help. The chapter further discusses the competitive features of the dual user interface and of supplied functionality compared to existing electronic books. It also consolidates the key design findings, elaborating on prominent design issues, design rationale, and respective solutions, highlighting strengths and weaknesses, and outlining directions for future work.

50.2 Background and Related Work

50.2.1 How Do Blind People Use Computers?

In order to access computers, blind people employ two basic technologies: (1) text-to-speech, and (2) Braille displays (see also...
Chapter 6 of this handbook). Text-to-speech technology allows the dynamic reproduction of any text using a humanlike voice. Braille is a writing system that uses six to eight raised dots in various patterns to represent letters and numbers. Due to its tactile nature, Braille can be read through touch. A Braille display is a hardware device that provides tactile output, mimicking the way blind people read Braille text on paper. A Braille display is composed of numerous “cells” (usually 40, 65, or 80) each of which contains 8 rounded plastic or metal pins that can be mechanically lifted, thus displaying a single ASCII character. Braille displays work complementary to text-to-speech. It is generally considered that speech is for speed and Braille is for accuracy. For example, a spelling mistake can be more easily detected on a Braille display than through speech. The most prominent input device for the blind is the keyboard, but in some cases the mouse is also employed.

The aforementioned technologies are used in combination with a screen reader, a software tool that can interpret what is displayed on the screen and convert it either to speech or Braille (see also Chapter 28 of this handbook). The most popular screen readers are JAWS by Freedom Scientific, Hal by Dolphin, and Window-Eyes by GW Micro. Since screen readers only present one word at a time (either through speech or Braille), it is very difficult for a blind person to get an overview of the current screen’s layout and content. In fact, it is said that it is the equivalent of a sighted person trying to look at the screen through a straw.

50.2.2 Electronic Books

Electronic books are software applications that adopt the book metaphor in order to render multimedia content (text, images, audio, etc.) on a computing device, while providing related functionality, such as page browsing, table of contents, and bookmarking (see Chapter 46 of this handbook). The electronic files that contain the educational content are usually referred to as e-books (or eBooks), while the terms reader or player usually denote the interactive software applications employed for reading e-books. Currently, few such players exist that are accessible to visually impaired people, while offering high quality of interaction for content presentation and navigation. The key advantages of e-books compared to their printed counterparts with regard to accessibility by the blind are the following:

- They can be automatically read using a speech synthesizer, thus allowing eyes-free access.
- They can be rendered on a Braille display, thus allowing tactile access.
- They do not have to be physically held or flipped, thus allowing hands-free access.

Currently, there are a few new file formats in which an e-book may be created. Few of them are compatible with each other, but most them are not. In most cases a different reader application is required in order to render each format. Based on their intended use, available formats can be broadly classified in three categories:

1. General-purpose formats: Formats that are not only used for creating e-books but also for any kind of text. The most representative examples include the following:
   (a) Plain text: ASCII characters with no formatting of any type. It has a very small size and can be accessed by any application. Its main disadvantage is that, since it does not include any kind of semantic information (e.g., headings, sections), the rendering, navigation, and interaction options that can be supported are very limited.
   (b) Hypertext markup language (HTML): The language used for creating web pages. E-books created in HTML can be read using any web browser (e.g., Mozilla Firefox, Microsoft Internet Explorer, Apple Safari). E-books created in HTML require more space than those in plain text, and their creation requires some programming skills or the use of related interactive tools.
   (c) Portable document format (PDF): A format invented by Adobe Systems mainly to create documents the visual properties of which remain the same, independently of the software tool or platform used to read them. Since this is a proprietary format, specific software tools by Adobe are required in order both to create and read such documents. Currently it is considered the most popular e-book format.

2. General-purpose e-book formats: Formats that can only be used for creating e-books, such as:
   (a) Microsoft LIT: A proprietary format created by Microsoft. Books in this format can only be read by using the Microsoft Reader program.
   (b) IDPF epub: An open standard created by the International Digital Publishing Forum.
   (c) Mobipocket: A format based on the Open eBook standard, which is quite popular in portable devices since readers exist for most Windows, Symbian, Blackberry, and Palm operating systems.

3. Accessible e-book formats: Formats used for creating accessible e-books (mainly by the blind), which are also referred to as digital talking books (DTBs):
   (a) Digital Accessible Information System (DAISY): A standard aiming to make print material accessible and navigable for print-disabled persons, more formally known as ANSI/NISO Z9.86 (ANSI/NISO, 2005). Most digital talking books for the blind are based on this standard. It defines the format and content of the files comprising a DTB and establishes a set of requirements for DTB playback software and devices. DAISY e-books can contain text, audio, or both.
   (b) NIMAS: A new standard format recently established by the National File Format (NFF) Technical Panel to
facilitate the provision of accessible versions of print textbooks to Pre-K–12 students with disabilities (NFF, 2005). NIMAS is actually a subset of DAISY aiming to simplify the markup complexity of the original standard by defining a minimum set of requirements for compliance. This format currently can only be used for literary-based textbooks, since mathematics and science textbooks are not supported.

50.2.3 Accessible e-Book Reading Applications

Available solutions can be broadly classified in two categories:

- Partially accessible e-books that integrate reading capabilities or are compatible with popular screen reading software
- Digital talking books developed specifically for use by blind people

The most widely used applications in the first category are the Microsoft Reader and the Adobe Reader. The Microsoft Reader (Microsoft, 2006) is equipped with quite elaborate navigation control and has a text reading feature that, however, does not work for copy-protected e-books. In addition to that, a Verbosity feature is supported, through which the current interaction focus is announced by tracking the movement of the mouse and keystrokes. This feature tries to reproduce part of the functionality offered by screen readers, since the Reader's compatibility with such applications is not guaranteed (Microsoft, 2002), but user keystrokes are not spoken, and thus user input is not accessible. Users can read an e-book from the last point they left it, or from the farthest page they have read and also get brief information about their current location in the e-book. The Adobe Reader (Adobe, 2004; WebAim, 2006) also has a Read Out Loud option, which, using an embedded speech synthesizer, can recite the contents of a PDF document but does not provide any navigation controls. Users can affect, to a limited extent, the reading order strategy and can also select to open a document to the last section where they left off. In order to achieve a higher level of accessibility, Acrobat Reader is made compatible with screen readers. Recently, Adobe has released Adobe Digital Editions, a free e-book program designed especially for PDF-based e-books. Unfortunately, unlike the Acrobat Reader, this application does not presently include any accessibility features.

In short, the major drawbacks of software belonging in this category can be summarized as follows:

- Unless a screen reader is used (when and if possible), only a very limited part of the available functionality is accessible to the visually impaired users. But even then, there are several usability problems associated with screen readers (Barnicle, 2000; Parente, 2006), which also have a high cost, and, as a result, are used only by a small percentage of blind people.
- These programs have a graphical interface that is optimized for visual use. Thus, in order for users to effectively use them, they must possess an accurate mental model and a good understanding of their visual structure and layout. These facts impose an unnecessary high mental workload, and result in erroneous, painstaking interaction.
- Feedback to most user and system events is provided solely through visual cues, thus leaving the nonsighted users wondering about the effect of their actions, or the current state of the interaction process.
- The overall effectiveness, efficiency, and quality of nonvisual interaction are quite poor.

Regarding digital talking books for the blind, the National Information Standards Organization has suggested specific guidelines for hardware/software platforms (i.e., players) that render the contents of a DAISY (NISO, 1999). Several related software applications that use the DAISY format (e.g., FSReader by Freedom Scientific, gh PLAYER by gh, Victor Reader Soft by Humanware, EaseReader by Dolphin, eClipReReader by irit) but also hardware devices (e.g., PlexTalk by Plextor, ezDaisy by Telex, Victor Reader by Humanware) are available. All of them mainly provide speech output, and only one supports Braille displays.

As DAISY books have an explicit and well-defined structure, related players usually offer several alternative ways for navigating in the book's content (e.g., table of contents, browse headings, move directly to a specific location). Furthermore, typical features supported include bookmarks, information about the current position and the total length of the book, remembering the user's last position, note-taking, and highlighting.

50.2.4 Research Applications

Accessible to the Blind

In addition to commercial software, a few research systems have also been developed that aimed to improve the access of people with visual impairments—and especially for the blind—to printed material.

DAHNI was an early hypermedia system with a nonvisual interface (Petrie et al., 1997). The system could be used with three input devices: keyboard, joystick, and a custom-made touch-tablet. All available commands were logically arranged on two-dimensional space, in a sideways H shape. The user would always start from a central point and then navigate through the available commands using the various input devices. Shortcut keys were also supported for expert users.

VoxBoox (Jain and Gupta, 2006) is a prototype system that automatically translates books published in HTML to VoiceXML that is enhanced with additional code in order to allow speech-based user interaction through a small set of commands (e.g., go to the beginning or end of the document, start/stop reading). Additionally, speech bookmarks can be inserted on a page or paragraph, so that, later on, users can return to it by uttering the bookmark's name.

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Some more loosely related work that deals with nonvisual access to information, but not in the form of an e-book, includes:

- Research efforts that address the problem of accessing mathematics nonvisually, for example, MathTalk (Stevens et al., 1997), AudioMath (Ferreira and Freitas, 2004), Math Genie (Karshmer et al., 2004); see also Chapter 51 of this handbook.
- The Hyperbolic Browser, a tool for navigating hierarchical structures to aid nonsighted programmers (Smith et al., 2004)
- The AVANTI web browser (Stephanidis et al., 2001) that can adapt itself for nonvisual access to the web
- HOMER (Savidis and Stephanidis, 1995), a user interface management system, which facilitates the development of dual user interfaces

### 50.3 The Starlight Platform

A key limitation of existing e-books that are accessible to the blind is that they are mostly designed to support the reading of novel-like books by a single end-user. Critical features that typical educational textbooks support, like recapitulation questions, exercises, exams, and personal annotations, are totally missing. Additionally, they lack functionality that is necessary for deployment in an educational setting, such as:

- Logging a student’s progress (e.g., which content has been read and for how long)
- Provision of related statistics
- Full content editing by the educator
- Configuration of functionality to the student’s characteristics, abilities, and requirements
- Concurrent student-educator use
- Support for multiple registered users

In this context, the rest of this chapter presents the development of an educational textbook platform, namely the Starlight platform (Grammenos et al., 2007), supporting all the various features previously mentioned, as they are not offered by available accessible e-books through a dual user interface, an interface that is manifested through alternative modalities and is concurrently appropriate for both visual and nonvisual use.

The platform comprises two subsystems:

- The Writer, facilitating the authoring of electronic textbooks, encompassing various categories of interactive exercises (Q&A, multiple choice, fill in the blanks, etc.)
- The Reader, enabling multimodal interaction with the created electronic textbooks, supporting various features like searching, bookmarking, replay of sentences/paragraphs, user annotations/comments, activity recording, and context-sensitive help

### 50.3.1 Development Process

The development process adhered to the basic principles of human-centered design (ISO, 1999) with the direct involvement (in different parts of the process) of two usability experts, two accessibility specialists, three specialized educators, four blind students of varying ages and two of their parents, in total. During the very early design phase, it soon became apparent that the goal of delivering a dual user interface for such comprehensive e-book functionality was highly demanding, requiring far more intensive iterative design than typically required. In this context, very quick iterations were conducted involving many design, prototyping, and evaluation sessions. For this purpose, a discount usability method was adopted (Nielsen, 1993, 1994; Wharton et al., 1994). The details of the design process are presented in Figure 50.1.

First, a requirements and task analysis phase took place, collecting data from:

- Relevant bibliography (e.g., Graziani and Arato, 1998; Morley, 1998; Smith et al., 2004)
- Commercial products
- Accessibility experts
- Target users
- Assistive technology experts
- Software engineers

The analysis of the collected information has led to the identification of the primary functionality and the preliminary interaction design, including several annotated paper sketches and digital mockups. These mockups were reviewed by a team comprising a usability expert, an accessibility specialist, an educator of students with visual impairments, and a lead software engineer. Following their comments, the initial version of the design specification was created (see Figure 50.1).

Next, the initial implementation of the system, encompassing the functionality and the user interface, was carried out. From this point on, expert evaluation (based on heuristic evaluation; Nielsen, 1994) was repeated after every user interface feature becoming available or modified; the latter was practically required many times per day. Every week, the overall platform was tested with end-users, adopting a combination of the Thinking Aloud (Nielsen, 1993) and Cognitive Walkthrough (Wharton et al., 1994) methods. The results of both processes were compiled in a prioritized list of suggested corrections and improvements. Then, this list was discussed, filtered, and finalized in a plenary meeting, based on criteria of criticality, feasibility, and development cost.

### 50.3.2 The Starlight Reader

This section elaborates on the key interactive properties of the Starlight Reader, presenting the corresponding design rationale, and discussing how the final design decisions were shaped by the feedback from the iterative evaluation sessions.
50.3.2.1 Multimodality

As previously mentioned, the Starlight Reader has a dual interface comprising a visual and a nonvisual manifestation. The visual interface has similar function and use as any other Windows application. The nonvisual interface is rendered through synthetic speech, via two different voice types interchangeably—male and female—as well as through Braille displays. During the requirements analysis phase, it became apparent that the concurrent use of speech and tactile modalities was prominent, as these two modalities had to be deployed for different aspects of interaction. Speech is faster and easier to use, especially for younger students who are in the process of learning Braille, but on the other hand, accuracy and text comprehension is significantly better with Braille (Garcia, 2004). User input is supported through the keyboard, the Braille display's hardware keys, and any type of joystick that has at least two buttons. In particular, joystick support can considerably aid the use of the system by younger children, since it is very easy to master and requires virtually no training.

50.3.2.2 Interaction Metaphor

Starlight adopts the metaphor of an electronic book, but with a variation: its content is still decomposed into chapters, sections, subsections, paragraphs, and sentences, as any typical book, but not in pages. This decision was deliberately taken due to the fact that e-books do not have to be confined by a visual restriction inherent in the physical medium used to instantiate printed books in the past. A paper page simply represents an arbitrary quantity of text, with no particular semantic connotation. In the digital world, especially when text is rendered nonvisually, this concept is meaningless and mostly misleading. In fact, it comes as no surprise that document authoring tools support automatic paging, since a page never constitutes a semantic element of the document structure, like sections or headings. The conducted expert evaluations and user tests validated this decision.

In general (see Figure 50.2), a book can contain an arbitrary number of chapters, each of which can contain text, organized in subsections of any depth, notes, exercises, and exams. Four

![Figure 50.1: Outline of the development process.](image)

![Figure 50.2: Structure of a Starlight book.](image)
different types of exercises are supported: (1) multiple choice; (2) true/false; (3) fill in the blank; and (4) open-ended questions. Additionally, a sentence may include an internal link to any other position in the same e-book. The difference among recaptulation exercises that can be added at the end of each section and exams is the following:

- Recaptulation exercises can be accessed by the student as part of reading the book and while taking them. The student:
  - Is allowed to access any other part of the book
  - Directly gets feedback about correctness after providing an answer and not an overall score for all of them
  - Can attempt to answer a single exercise multiple times
- Exams can only be triggered by the educator and during them the student:
  - Is not allowed to access any part of the book
  - Can move freely among the exercises and answer them multiple times, but gets no feedback about their correctness
  - Has to explicitly state when she has completed the exam in order to get a report that contains a score and summary of the results, as well as a detailed list of all the exercises, of the answers, and whether these were correct or not

In order to be able to support the novel functionality that was required by Starlight, a new, custom-made, e-book format was used, instead of one of the currently available standards such as DAISY (ANSI/NISO, 2005) and NIMAS (NFF, 2005). The present version of this format does not support text formatting or images, but it is foreseen that this will be included in a subsequent version.

50.3.2.3 Sharing

In a typical school setting, a single computer is usually shared among several students, each of whom has individual interaction preferences, bookmarks, and notes, as well as data related to examination and test results. Unlike other e-book rendering applications, Starlight e-books support multiple students, automatically keeping track of personal preferences (e.g., voice volume and speed), content viewed, progress, exercises completed, and exam results, as well as where the student left the book.

50.3.2.4 Dual Interaction

A problem may arise in an inclusive educational setting in the case where a blind student collaborates with a sighted peer (student, teacher, parent, or friend), or the opposite. If the e-book is rendered exclusively nonvisually, such collaboration and social interaction is not possible. If the e-book has a Windows-based visual interface and is also compatible with a screen reader, then it can be presented nonvisually, but as mentioned earlier in Section 50.2.3 the interaction quality of the nonvisual interface can be considerably, or even unacceptably, compromised.

To overcome such problems Starlight implements two distinct user interfaces through nonoverlapping input/output (I/O) modalities that can work in parallel without conflicts. Thus, nonvisual use is achieved through the keyboard, speech synthesis, and Braille, while visual use is achieved through a graphical interface and the mouse.

50.3.2.5 Navigation

Navigation in electronic texts constitutes a key challenge for most users, and several solutions for improving its usability have been suggested (e.g., Shubin and Meehan, 1997). Typically, most approaches aim to effectively address context control, usually referred to as the "Where am I?" issue. In a visual setting, there are various ways to support navigation (e.g., using different font size and colors, layout) relying on immediate visual perception. However, such techniques do not apply to speech or Braille modalities, due to the sequential delivery of content, and to the fact that auditory information, in contrast to visual, is transient (Morley et al., 1999). In this context, existing navigation techniques have been integrated or adapted (e.g., Graziani and Arato, 1998; Morley, 1998; Morley et al., 1999; Smith et al., 2004), and new ones have been designed:

1. Control over the auditory presentation of information
   - Play and stop: A single key (ESCAPE), which due to its placement on the keyboard, is the most easily, rapidly, and unmistakably accessed key by a blind person.
   - Repeat: The last sentence heard.
   - Navigate in the book's structure: To the table of contents, to the start of the book, to the next/previous sentence, paragraph, section, or chapter, to the exercises or notes of the current section. From the table of contents, the user can also access the time spent in each of the chapters, sections, subsections, and so on.
   - Navigate inside a sentence (i.e., spelling mode): To read the current sentence or the current word, go to the start or end of the sentence, move to the next/previous word or letter. When single letters are read, information is also provided such as whether the letter is capital, if it has an accent, and if it belongs to a language other than the text's "native" one.
   - Control speech volume and rate.
   - Single-key navigation: Special care is taken so that a novice user can interact without having to rely on multiple keys and shortcuts. Thus, it is possible to go through all the initial dialogues (book selection, user login, start position) and browse all of the contents from the very first sentence till the end, using just a single key (which by default is set to be the right arrow).
   - Start-up options: When an e-book is opened, the user has the options to go to the last position where she left off, to the table of contents, or to the book's start.
2. Support of hypertext controls and tools

- **Move back and forth in the navigation history:** This feature is very useful in nonvisual applications, because it helps users return to a prior location when they are accidentally transferred to another one (e.g., due to the press of a wrong shortcut).
- **Bookmarking at sentence level:** Existing applications support bookmarking a page but not a specific point in it. This is impractical, as a blind person has to read through the entire text to locate the actual point of interest that was the reason of the bookmarking. In Starlight, bookmarks can be added to sentences. Furthermore, when a bookmark is read, its context (chapter, section, paragraph, etc.) is also described, so that users can easily identify the target of the bookmark.
- **Search:** The results are presented in a list, each entry carrying context information (chapter, section, etc.). When a list item is selected, the user is transferred to that point, with the option to jump to the position of the next or previous search result without returning to the results list.

3. Provision of context information and interaction safeguards

- **Where am I?** A precise description of the current context is provided. The description is created bottom-up, starting from the relative position of the current paragraph in the current section (e.g., "paragraph 3 out of 5"), all the way up to the top level (e.g., "section 2 out of 4 Section Title, chapter 4 out of 10 Chapter Title"). If the user is currently using a support facility (e.g., bookmarks, notebook, search), the name of the facility is also read.
- **Return to the last position in the book’s content:** Users may directly return to their last position in the content from anywhere. This works as a safeguard, since practice has shown that users are often lost while using the book’s support tools or interface and need a meaningful place (or interaction state) to return.
- **Different voice for rendering interface and content:** In a speech-based application, it is often difficult to distinguish between content and interface, since they both are rendered as words, which are often interwoven. In order to differentiate among the two, Starlight employs two distinctively different voices (i.e., male and female). As was revealed during evaluation, this feature had a significantly positive impact on the overall usability of the Reader.
- **Automatic section numbering:** Hierarchical section numbering (e.g., 3.7.1) can provide valuable and intuitive context and navigation clues. To ensure the consistency and accuracy of section numbering, it is automatically generated by the Reader.

4. Nonspeech auditory feedback: In auditory interfaces, a convenient way to provide feedback while avoiding speech overuse is nonspeech audio in the form of either structured combinations of musical sounds (or earcons; Stevens et al., 1995) or natural, iconic sounds that work just like metaphors. In Starlight, sounds are deployed to denote the initiation or completion of specific actions and events, adopting distinct everyday sound effects (e.g., Mynatt, 1997) for the following actions:

- Add a bookmark.
- Denote that the current text contains a link.
- Move to next or previous section/chapter.
- Focus is transferred to another part of the book through the table of contents or by following a hyperlink, a bookmark, or a search result.
- Notebook open/close.
- Speech volume is changed.
- Spelling mode is switched on/off.

50.3.2.6 Context Sensitivity

**Task-based context-sensitive menu:** At any time a nonvisual menu can be activated with the commands supported in the current context. The menu is structured at two levels: on the higher level are user tasks, and within each task, the supported functions.

**Task-based context-sensitive help:** Help is provided for the available functionality for the active user tasks. Help content is structured similarly to the nonvisual menu.

50.3.2.7 Adaptive Prompting

Whenever the system waits for user input, or it is anticipated that the user intends to perform a certain action, the system prompts these actions together with the corresponding shortcuts. Typical cases concern yes/no dialogues, exercises, exams, the table of contents, and so on. This information is always provided at the end of the dialogue, so that the user may quickly skip it. Additionally, there is a shortcut exploration mode, where, whenever a shortcut is pressed, the system automatically announces the associated function. This feature was suggested during early formative evaluation sessions by a blind student.

50.3.2.8 Configurability

Since nonvisual applications unavoidably rely on the use of shortcuts, it is crucial that users may redefine them according to individual preferences and needs. The latter is fully supported, detecting and resolving also potential conflicts among shortcuts.

50.3.2.9 Integrated Text Editing

Starlight includes a nonvisual text editor that is used whenever text input is needed, for example, in the notebook, open-ended questions, and notes. This editor supports bilingual editing (Greek and English) and works as follows:
Cursor: It is implicit, representing a character position inside the text. Insertion is performed after the current position, moving the cursor to the newly inserted character.

Key press: It is read. If it is a letter, it is stated if it is capital, accented, or in English. If no key is pressed for a while, the entire current word is read.

Navigation: Move the cursor a character/word to the left/right, to the start/end of the current sentence or whole text. When the cursor is moved, the word in that position is read, followed by the character at the cursor position.

Copy/paste: From user tests it was found that using the typical keyboard-based MS Windows approach for selecting a piece of text (i.e., keeping the Shift key pressed while also using the arrow keys to select text) had several usability problems. For example, according to this technique, if the Shift key is pressed, then the selection is lost and the user has to start over again. Also, it requires two hands, thus prohibiting blind users from concurrently using the Braille display to locate precisely the text to select. To overcome these problems the user presses a shortcut (or selects the related option from the nonvisual menu) to anchor the start point of the selection, and then using the arrow keys can freely move to the end of the selection. Then, via the menu or through shortcuts, the selected text can be copied or cut.

Reading: The user may listen to the current word or sentence, the selected text, or the entire text.

50.3.2.10 Embedded Notebook

Users may swap at any time between the e-book and the notebook in order to keep notes of what they read, write down questions, and so on. A feature that was appreciated during user testing is that the currently spoken sentence can be directly copied to the notebook, making very easy the creation of outlines and summaries of the text as it is read. Furthermore, more advanced users can insert custom anchor points (i.e., quick access bookmarks) in their texts. Notes can also be added to each section, either by book authors at creation time (e.g., references, explanations, comments) or by the students during reading.

50.3.2.11 Adaptable Levels of Functionality

The goal of Starlight was to create a tool addressing a wide range of student ages, from the first grades to university levels. The Starlight platform offers comprehensive functionality that may not be needed for particular target users. Additionally, educators may wish to introduce all available functionality incrementally, starting with the very basics, and moving toward more elaborate options. For this purpose, every function offered by the Starlight Reader can be ranked using a number, and then the e-book author/editor can tune the ranks of functionality actually exposed to the end-users (e.g., the students).

50.3.2.12 Privacy Considerations

As a blind user has noticed during evaluation, in contrast to a sighted person, a blind reader may not be aware of whether someone else is staring at the screen. For example, in a school setting, there might be other students copying answers, or the student may wish to keep writing/notes private from the tutor until done. To proactively avoid such situations, Starlight offers the option of blanking the screen, and having feedback of this state, in order to protect privacy.

50.3.2.13 Accessible Utilities

Every part of the Reader is accessible, including utilities such as the installation tools, book selection, and user management. Furthermore, the full user manual is provided with the Reader as an e-book itself.

50.3.2.14 Visual Interface

The visual interface of the Reader supports sighted users and users with deteriorated vision, and is targeted to peers with a supervisory role (teachers, parents), friends, or other students.

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FIGURE 50.3 The visual interface of the Starlight reader.
Besides speech and Braille output, unlimited font and interaction object magnification is offered. The main interface (Figure 50.3) consists of the following parts:

- **Main menu**: Contains some general functions, such as alternative help (shortcuts, context-sensitive, user manual) and visual layout options (which components to show/hide).
- **Commands toolbar**: Provides direct one-click access to the most frequently used and needed functionality. The toolbar is context sensitive, as it is dynamically populated with functions that are relevant to the task at hand.
- **User information**: The user’s name and the time that has passed since she started reading the book.
- **Book structure navigator**: Presents the book’s structure. Users can reveal or hide a node’s contents and can jump to a specific section by double-clicking on it. This function is particularly useful when an educator wants to quickly transfer a student to a particular position in the book. The user’s current position is noted with bold letters, while unread sections are marked with red.
- **Section’s contents**: Comprises four tabs, each one respectively containing a list with all the available exercises, exams, paragraphs and notes of the section that is currently selected at the book structure navigator. Users can jump to any one of them by double-clicking.
- **Main part**: May contain the following tabs:
  - **Content**: This is where the book’s contents are graphically rendered. The sentence that is currently being read is presented using blue color and a much larger font.
  - **Notebook**: Here the contents of the nonvisual notebook are presented (see Section 50.3.2.9) and edited.
  - **Exercises and exams**: If, during the current session, the student has taken any exercises, an extra tab is added, which contains detailed information about the exercises’ content, the student’s answers, as well as whether these were correct. The educator has the option to save or print the contents of this tab. Similarly, additional tabs are added whenever the student takes any exams.
  - **Logging and statistics**: This section has three tabs containing the student’s: (1) navigation history (i.e., which sections she has visited and for how long); (2) a list of past exams’ reports (that then can be opened to the “main part”); and (3) summarizing statistics about all the exercises that she has answered since she has started using the book.

In order to enhance the efficiency and usability of the Writer the following global interactive features are supported:

- **In-place context-sensitive menus**: The user can access related functionality for any part of the user interface through a menu that appears by pressing the right mouse button.
- **Undo/redo**: In order to avoid accidental loss of the user’s work, an unlimited number of undo and redo actions is supported.
- **Cut, copy, and paste at any level**: Information of any type can be cut, copied, and pasted in any relevant place in the book. Thus, for example, a whole chapter with all its content can be duplicated, a subsection from a specific depth can be moved to another depth, multiple exercises can be exchanged among sections, and so on.
- **Context-sensitive help**: Through the respective menu option or by pressing F1, users can get help that is relevant to their task at hand.

The basic interface of the Writer (see Figure 50.4) consists of the following parts:

- **Main menu**: All the currently available functions can be accessed through this menu (e.g., open, save and close a book, search/replace, change interaction options, get help). Depending on the current context of use, some additional menus may appear.
- **Toolbar**: Supports quick and direct access to the most commonly used functions.
- **Book contents tree**: Provides an overview of the book’s contents and also works as an easy and efficient navigation mechanism.
- **Current path (Where Am I?)**: Illustrates the path (i.e., the place in the book’s hierarchy) of the piece of content that is currently being modified. For efficient use of space, only the numbering of the headings is included in the path and not their full titles. The current level is presented using a black, bold font. Previous levels are rendered in blue color and also work as hyperlinks, allowing users to easily move to higher levels.
- **Section title**: The title of the section being edited.
- **Sequential navigation buttons**: Three buttons used for browsing the book’s contents in the same order that they are read by the Reader. One of them is used moving one level up in the book hierarchy, while the other two lead to the previous and next section respectively.
- **Content editor**: This is where the actual editing takes place. Its content and function changes dynamically depending on the type of the content (e.g., the book’s table of contents, a specific section’s contents). The content editor has a separate toolbar, which also adapts to the current context of use. When editing a section of the book, this area comprises the following components:
  - **Text editor**: Contains the actual text of the current section. The active sentence (i.e., based on where the

### 50.3.3 The Starlight Writer

The Writer facilitates the authoring of electronic textbooks that can be accessed through the Reader. Currently, the Writer has only a visual interface and thus is not accessible to blind people. The Writer supports versioning (i.e., keeps track of the book’s edition number) so that updates to existing books can be created.
cursors is located) is highlighted. If a sentence contains a link, it is underlined. By moving the mouse over such a sentence, a tooltip appears describing the link’s target. The text editor provides facilities for reading the current sentence, a piece of selected text, or the whole text, using the same voices and attributes as the Reader. This is a very useful feature, since very often alternative speech synthesizers render text in a different way, a fact that may result in changes in the written text. In addition to that, the Writer supports the use of alternative configuration files for the available speech synthesizers, thus allowing for respective speech adjustments.

- **Subsections**: A list containing all the subsections of the current section.
- **Notes**: A list of notes related to the current section.
- **Exercises**: Exercises for the current section. A single exercise may be shared among different sections and exams, thus allowing for reusability and easier maintenance.
- **Exams**: Available exams for the current section.

### 50.4 Evaluation

As mentioned earlier, usability and accessibility evaluation constituted an integral, inseparable part of the iterative development procedure. In addition to formative evaluation iterations, testing in real practice was performed. Some of the evaluation findings have already been mentioned in the previous section, in order to justify, explain, or support some of the presented interaction design decisions. This section refers to additional findings, some of which constitute pointers for future work and software extensions.

The Achilles’ heel of Starlight, as of any other system that uses synthesized speech, is the quality of the synthetic voices. Although all of the users that owned a screen reader admitted that the quality of the Greek speech synthesizer used in Starlight (“Ekfonitis”) by ILSP was much better than theirs, there still is a great distance to cover among synthetic speech and digitized recordings by professional narrators. The key related problem is the lack of intonation that has a negative impact on comprehension and also tires listeners after a certain period of time. Thus, when users were asked about what they thought needed to be improved, they almost unanimously responded “the voices.”

Another problem of speech synthesizers relates to content creation. Each speech synthesizer reads the same text in a different way. Also, some are capable of using the context of a word to infer its correct pronunciation, while others do not. This practically means that, to create content that can be read consistently and correctly by all synthesizers, extensive manual processing of the material is required.

Another problem was related to the overall interaction, with an emphasis on user assistance. Nonvisual interaction can be quite challenging for novice users, mainly because, explicitly or implicitly, it relies on different states (or contexts). This is unavoidable, since sound (but also the Braille display) is a sequential medium, and thus only one thing can be presented at a time, unlike, for example, GUIs, where help and guidance messages can be presented in parallel with the main interface. Consequently, the user has to mentally keep track of the current context, and the user may get lost if a single change of state is not noticed. Starlight includes several methods to ensure that content changes are sufficiently highlighted, and that the user can easily retrieve the current context. Still, the main drawback of these solutions is that they are reactive, that is, the user has to do something (e.g., press the Help button, use the menu) to get some guidance, but in some cases the user may not be in a position to do that. Thus, what is additionally needed is to provide 2

2 http://www.ilsp.gr/ekfonitis_plus_eng.html.
proactive methods (e.g., an intelligent agent) that by monitoring user activity (or inactivity) will be able to infer such problematic situations and take the initiative to remedy it.

In the same context, a popular user request was the provision of an interactive tutorial that would substantially facilitate learning how to use Starlight.

Finally, users suggested that the Starlight Reader should be also able to present:

- **Images**: Providing magnification and change of contrast options for those with deteriorated vision and hierarchical navigable descriptions for the blind.
- **In-line sounds**: Inserted throughout the text to annotate or make it more interesting and vivid.
- **HTML pages**: A lot of educational texts are already available on the web, and users said that they would prefer to use Starlight to read them instead of a web browser with a screen reader; educators also stated that they would like to import them to existing e-books or to create new e-books.
- **Mathematics**: As they constitute a significant part of educational material for many lessons. A challenge here is how to render mathematics on a Braille display, since most of the time their presentation requires multiple Braille lines (see Chapter 51, "Mathematics and Accessibility: A Survey").

Overall, the opinion of all stakeholders (potential users, educators, specialists) about Starlight was very positive, as it is designed to support teachers and students by directly addressing existing, real needs and effectively addresses a substantial lack that schools with blind students faced up to now. Of course, there is still much room for improvements and extensions, but currently—at least for Greek schools—Starlight constitutes the only available fit solution, thus opening a new dimension to the educational process.

### 50.5 Conclusions and Future Work

This chapter has discussed the concept of electronic books and how they can be used to provide accessible educational textbooks to blind students. In this context, the Starlight platform for creating and reading such books was presented. More specifically, the user-centered development process followed was highlighted, as well as the interaction design characteristics and rationale of the Starlight Reader, as these were shaped after numerous iterations of evaluations both with experts and potential end-users.

In summary, the Starlight Reader builds upon the characteristics, findings, and recommendations of past related work, and extends it with novel features that on the one hand improve the usability and accessibility of electronic books, while on the other hand can considerably support the educational process by directly addressing specific related needs. Some of these features are:

- Single-key interaction
- Dual voice for separating the content from the user interface
- Bookmarking down to the sentence level
- Automatic section numbering
- Embedded on-demand notebook
- Supporting interactive exercises and examinations
- Adaptable functionality level tuned by educators
- Logging and statistics per student
- Integrated authoring support

The Starlight platform has been used for the development of eight related products. The educational content for these products was provided by Savalas Publications, a leading publishing company for Greek educational books, and was adapted in order to be suitable for use by blind students, in cooperation with the Panhellenic Association of the Blind and specialized educators. This content was transformed into e-books using the Starlight Writer. Starlight e-books can work with any speech synthesis engine that supports Microsoft’s Speech Application Program Interface (SAPI). The aforementioned Starlight products also include the "Ekfoniitis+" text-to-speech system developed by the Institute for Language and Speech Processing - ATHENA.

Future work includes developments to support:

- Text formatting, in-line images and sounds
- Importing e-books written in HTML, DAISY, and NIMAS
- Rendering mathematics visually on the screen, as well as through speech and Braille
- Nonvisual presentation and navigation in information-augmented images
- Deployment of the Starlight Reader on mobile devices such as 3G phones and personal digital assistants (PDAs)
- Creation of a dual user interface for the Writer, so that blind students can also edit the content of the books, or even create their own

### References


