Education Department
Accessibility Group
Educational Platforms

GUIDELINES FOR THE DESIGN OF ACCESSIBLE EDUCATIONAL ENVIRONMENTS FOR PEOPLE WITH VISUAL IMPAIRMENTS

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1. INTRODUCTION

The present guide is intended for all the professionals involved in the development of educational environments. If the principles it contains are implemented from the content specification and design phase, the resulting environments will be more readily usable by blind or visually impaired students. While many of the guidelines discussed hereunder are applicable to users with disabilities in general, the focus in the present text is on users with visual impairments.

Together with practical suggestions for the design of computer software itself, the guide discusses educational criteria relating to the most suitable structure for the presentation of content, based on teaching experience with visually impaired students.

This guide aims not to promote the design of any specific type of educational environments, but to further the development of software designed for non-discriminatory - independent or joint - use, that benefit visually impaired students and their sighted classmates alike.

The guidelines are classified around the programming elements, content and learning methods most frequently found in today's educational software.

Throughout, the guide stresses the two basic objectives pursued in connection with computer programming namely:

1. To guarantee the co-existence of mouse-click and keyboard-command only operation of all functionalities.

2. To enhance perceptibility by blind or visually impaired students of all the significant information displayed, and the changes taking place, on the monitor.

2. OBJECTIVES

This guide intends to serve as a reference for all professionals involved in the development of educational environments and an aid to making such environments accessible to students with visual impairments.

Whilst the guidelines discussed hereunder may prove to be highly useful, due to the diversity of educational content, each environment developed should be the subject of an individual, detailed accessibility study.

The guide embraces all the areas involved in development, from software programming to graphic interface design and its connections to tools, aids and appliances for people with visual impairments, and, finally, the actual definition of educational content.

In light of the wide variety of professionals targeted (programmers, graphic designers, teachers, pedagogues, and so forth) and the continual changes taking place in the various fields of knowledge covered, this is meant to be a dynamic text that will be periodically revised and updated to include new ideas and eliminate any content that may grow obsolete.

The second objective sought is to justify the need to follow all these guidelines. This question is addressed in a series of specific annexes and appendices containing information that will prove particularly useful for professionals who have had no contact with teaching students with visual impairments.

3. TYPES OF SOFTWARE ACCESSIBILITY

From the standpoint of software use by people with visual impairments, there are two main approaches to accessibility:

- Standard software which, following a series of basic design guidelines, can be used with the aid of a screen reader.

- Software that is accessible in and of itself, with no need for any other tool. This is what is known as directly accessible software.

These guidelines discuss the design principles for both types of software, highlighting the features that distinguish standard compatible software from the directly accessible variety, which must meet slightly different criteria.

The objective is to cover design principles for both types of accessible software applicable to the entire range of education, from pre-school up.

In principle, the decision on which type of software should be developed is based on two factors:

- ✓ The age and level of schooling of the students targeted. Directly accessible environments are advisable for pre-schoolers and lower grade primary school pupils with visual impairments, who have not yet acquired the skills and strategies required to use screen readers.

- ✓ The technical complexity of the software to be developed, which is normally but not necessarily heightened by including directly accessible design.

Finally, regardless of the type of software developed, if installation is involved, that process must be wholly accessible for users with visual impairments. And any documentation directly or indirectly relating to the software must be in an accessible format as well.

4. DEFINITIONS AND ACRONYMS

Braille: Reading-writing code based on combinations of six dots arranged in a two-column, three-row matrix. This code is perceived by touch.

Heat Fuser: device that provides a source of heat to raise printed lines on swell or microcapsule paper.

Screen reader: program that directs the information on the screen to an output device such as a speech synthesizer, Braille display or both. It also enables users to interact with the computer by means of a series of keyboard commands and combinations.

JAWS: Screen reader developed by Freedom Scientific, presently the most popular product of its kind on the market (http://www.freedomscientific.com/).

Screen magnifier: Software specifically intended for visually impaired persons that enlarges the size of the elements on the computer display.

Braille embosser: output peripheral that prints information in Braille code.

Touch screen: computer screen that enables users to interact with software by simply touching the screen.

Swell paper: special paper that, when heated, bursts under inked areas, which then become detectable by touch.

Digitizing pad: peripheral that enables users to control a computer from a touch-sensitive pad by moving a special pencil across the pad.

Technical aids and devices: name given to technology applied to visual impairment, which includes an understanding of the techniques and resources that people with visual disabilities deploy to use standard technology. This enables designers to adapt information and communications technologies and make them accessible to and usable by this community.

Patterns: different fill styles and textures to differentiate the various areas of a drawing by touch.

WAI: Web Accessibility Initiative (http://www.w3.org/WAI/). Series of W3C working groups on different subjects relating to web accessibility.

5. GUIDELINES FOR DIRECTLY ACCESSIBLE SOFTWARE

This section discusses the design guidelines for directly accessible software, i.e., software with built-in voice or other messages for blind or visually impaired users, enabling them to operate the program in question without the aid of a screen reader.

As far as the constituent elements are concerned, the accessibility guidelines for this type of software are not very different from the guidelines for compatible computer applications. Therefore, only the aspects distinguishing the two are addressed in this section. Moreover, given that in educational environments this type of software will be developed especially for very young users, certain basic guidelines or recommendations are of particular importance and are listed below:

5.1. Access to the software should be immediate or via the shortest possible path from system start-up; exiting should also be simple, although subject to confirmation.

5.2. The software must be fully keyboard-operable. This does not entail disabling the mouse, but simply ensuring that the two options co-exist.

5.3. The shortest possible number of keys should be used, preferably the ones most readily located: the cursor keys, the number block, the space bar and escape and enter keys.

5.4. All screens or sections should be identified with a title, which should be announced in a voice message when the screen is first displayed.

5.5. A main menu should be displayed in all sections to provide access to any other part of the application.

5.6. The software should feature an option allowing users with disabilities to select text visualization options, software colour options and ink or Braille print options, or to print screens to be subsequently adapted with a heat fuser.

5.7. A verbal announcement or audio signal should inform users of any change on the screen, whether automatic or in response to some user action.

5.8. Each button or link should be identified by a voice message which should sound when the focus is on the element in question.

5.9. Voice messages should be provided for all texts and relevant information displayed on the screen that users should be able to play back as many times as they wish.

5.10. Pictures and photographs should be described in audio files.

5.11. The audio files provided with videos should contain a scene-by-scene description of the content.

5.12. All text and graphic elements should follow the same visual design guidelines as in compatible software.

5.13. Users should be able to choose their colour configuration (background, text, and so on) or, wanting that, the software should format to the user-defined colour combination in place for the operating system. In any event high contrast displays should be used consistently throughout (**see Appendix B**).

5.14. Users must be informed of the completion of an action by an audio signal, regardless of the result.

5.15. No matter which keys are established for navigating through the elements on each screen, navigation must follow a logical order (**see Appendix A**).

5.16. Keyboard navigation through screen elements should be circular. In other words, the last item on a list should be followed by a return to the first.

5.17. Keyboard navigation through menus should also be circular.

5.18. Elements common to all screens should always be located in the same position.

5.19. Information should be structured in the same way on all screens and/or software sections.

6. ACCESSIBILITY GUIDELINES FOR COMPATIBLE SOFTWARE

This section addresses the guidelines to be followed when designing software for use with the aid of a screen reader.

These guidelines are not enumerated in order of importance or priority; the degree of accessibility depends, rather, on the number of guidelines followed when drawing up the specifications for and designing computer software.

6.1. General guidelines for software use:

6.1.1. All software functionalities must be keyboard-controllable, although the mouse-click operating option should also be provided.

6.1.2. Users should be able to execute software whether the full screen or enlarged fields are displayed.

6.1.3. The visual layout should be the same on all software screens or pages.

6.1.4. Users should have quick access to any part of the application at all times, either from a general menu displayed on all screens or a map with direct access to the various functions.

6.1.5. Standard operating system controls are recommended for interacting with software wherever possible.

6.1.6. If the software is complex, users should be able to access the most crucial or common actions with screen reader short-cut keys.

6.1.7. Screens should be designed to be correctly visualized with a standard 800x600-pixel configuration, the format most commonly used by people with visual impairments.

6.1.8. The software should enable users to choose the colour configuration -background, text, and so on- or, wanting that, it should format to the user-defined colour combination in place for the operating system.

6.1.9. The software should have an option enabling users to select text visualization options, software colour options and ink or Braille print options, or to print screens to be subsequently adapted with a heat fuser.

6.1.10. A logical and consistent tabulation order between the software screen objects should be defined (**see Appendix A**), since in JAWS the focus is moved from one element to another with the tab key.

6.1.11. Application pages (other than tables of contents) should not be overloaded with links to other sections.

No more than five or six are recommended per page.

6.1.12. Eliminate redundant links on the same page or screen.

6.2. Graphics, graphic links and buttons

6.2.1. All graphic links should have alt-text (alternative text) descriptions of the action they perform.

6.2.2. They should be large enough to be readily identifiable on the screen.

6.2.3. Links should be enlarged or change colour when they have the focus.

6.2.4. Buttons or links performing the same action on all the screens or pages of an application, such as back, home, print and so on, should be the same throughout.

6.2.5. Button and graphic link design should be as simple as possible, preferably using basic geometric shapes.

6.2.6. Outlines should stand out on all elements.

6.2.7. Graphic button or link colours should contrast with the background colour of the screen.

6.2.8. If the button contains an image representing the action performed, it should colour-contrast with the button background.

6.3. Texts

6.3.1. Text should set against plain, single-colour backgrounds only, and never overlaid on images.

6.3.2. The software should preferably accommodate screen magnifiers; otherwise large text (minimum font size 14) and appropriate colours should be used (**see Appendix B**).

6.3.3. Users should be able to "edit" how text is to be read: in short phrases, word-by-word or even character-by-character.

6.3.4. Single column format is recommended for long texts which may be vertically scrolled as necessary.

6.3.5. Mathematical, physics or chemical formulas and musical phrases must admit special "Braille display" edition with a suitable editor.

Where this is not possible, they should be treated as a graphic element (**see 6.2**).

6.3.6. Certain graphic elements or features intended for structure or emphasis (boxes, background, colour or typographic changes and so on) need not be reflected in the Braille display or audio description, unless they are of fundamental importance; in such cases, audio illustration is preferable to a mere description.

6.4. Forms

6.4.1. Standard operating system controls should be used.

6.4.2. All elements on the form must be duly labelled.

6.4.3. Form element labels should not overlap with adjacent elements.

6.4.4. Drop-down lists must have buttons to execute the action associated with the option selected.

6.4.5. Multiple selection lists should be avoided as far as possible.

6.4.6. Forms should be enclosed inside a box or square that colour-contrasts with the screen background, to facilitate identification.

6.5. Videos

6.5.1. Videos must be designed to a large display size.

6.5.2. They must have a sound track (verbalization or sound label) synchronously describing the scene or variations displayed in the video.

6.5.3. Videos should have a manual start button, and should not start up automatically.

6.5.4. They must have a pause feature.

6.5.5. They must have a variable speed feature.

6.5.6. They must have a rewind-replay feature.

6.6. Tables

The following recommendations are based on the WAI guidelines for accessible table design in HTML format.

6.6.1. Tables should be avoided except as strictly necessary for readier comprehension.

6.6.2. Cells containing headings should be clearly distinguishable from cells containing data.

7. EDUCATIONAL CRITERIA FOR THE DEVELOPMENT OF SOFTWARE FOR VISUALLY IMPAIRED PEOPLE

The guidelines for educational software design introduced hereunder are intended to enhance didactic simplicity and content: that is to say, to ensure educational value.

7.1. All software developed for pre-school and the lower grades of primary education must be directly accessible.

7.2. All exercises and games developed must feature optional keyboard and mouse operation.

7.3. The number of keys needed to use pre-school software should be kept to a minimum.

7.4. If more than a certain amount of time lapses between student responses, they should hear a voice message encouraging them to complete the exercise.

The length of time in question will depend on the age of the pupils targeted, type of task, educational objective and so forth.

Wait messages such as “please wait” or “the game is being loaded” should be used to inform users that the software is loading or performing some internal task.

7.5. “Background sound” is indispensable to inform students that the program is active or remind them from time to time that a response is expected, as described above.

7.6. The software must clearly explain to students what they are expected to do at any given time.

7.7. Audio signals should be associated with success or failure when doing exercises or playing games and should be heard at every stage in the process, to transition between a reply and the next question.

7.8. Students must be informed immediately whether their answers are right or wrong.

7.9. Games calling for relating colours or shapes should be avoided, since blind children are unable to identify them. Sounds or images can be used instead of colours and shapes.

Where such elements are regarded to be indispensable, the respective haptic version must be provided, for use with “concept keyboards”, digital screens” or “digitizing pads”.

7.10. Games where the object is to identify and/or learn letters or numbers should have Braille display input/output, to enable children using this reading-writing code to learn the characters in the right alphabet.

APPENDIX A

Logical tabulation order

This appendix defines what constitutes suitable order for navigating through the elements of a page, with the tab or any other key.

When a page is opened, the user should first have access to the elements it contains, i.e., to the information provided by the page: first the title, followed by the text, graphics with the respective descriptions, and finally any buttons or links.

As navigation proceeds, users should access the general links for the entire application. These must be displayed on all screens.

Navigation should be circular, that is to say, users return to the first element on the page after exiting the last.

Although the standard order for exploring a page is from left to right and from top to bottom, elements that are similar or that perform similar actions should be accessed one after another, regardless of their geographic position on the screen.

Examples of text colours

The high-contrast text and background combinations illustrated below facilitate reading for people with visual impairments.

This is, however, merely a sample of the many combinations that may be used, not all of which are suitable for all types of visual impairments.

Finally, since type size and face also affect text legibility, large, clear letters are recommended.

Examples:

BLACK ON WHITE	**WHITE ON BLACK**
YELLOW ON BLACK	**WHITE ON BLUE**
WHITE ON RED	**BLUE ON WHITE**
RED ON WHITE	**YELLOW ON GREEN**

These are examples with combinations of basic colours -other combinations are also possible, with shades different from the ones shown.

Colour should be chosen to ensure the highest possible contrast with the surroundings and to distinguish between objects, text and/or empty spaces.

Technical aids and devices

There is presently a wide selection of hardware and software for visually impaired people on the market. This annex addresses some of the most common features of the aids and appliances designed to enable people with visual impairments to operate a computer.

A distinction should be drawn between:

- **Hardware:** electronic devices enabling visually impaired users to operate or interact with computers.
- **Software:** computer applications developed to facilitate computer use and access to the information provided by people with disabilities. It may be used in combination with hardware.

HARDWARE

Input/output peripherals that furnish the information generated by a computer in a form in which it can be accessed by the user.

The two chief types of hardware are speech synthesizers and Braille printers/embossers.

<u>Speech synthesizers</u>

These devices, used in conjunction with specific software, read out the information displayed on the screen.

They are no longer in general use, since voice output is now provided from the computer's own sound card, which is both less expensive and more convenient in terms of port connections and so on.

<u>Braille devices</u>

These are devices that plug into a computer and, with suitable software, allow users to convert the information generated into Braille code.

The most popular is the **Braille display**. This peripheral consists of a series of cells arranged in a line, each of which contains the dots used to generate Braille characters. The dots in each cell are raised or lowered on command from the computer to represent a given character.

Most of the models on the market feature certain basic functionalities that enable users more convenient access to information, such as special cells for detecting text colours and so on.

SOFTWARE

Specific applications have been developed that enable people with visual impairments to operate computers and access the information generated.

There are two chief types of software: screen magnifiers and screen readers, whose characteristics are described below:

Screen magnifiers

These programs, which enlarge the size of the objects displayed on the screen, are designed for use by people with residual vision. They feature the following:

- Scaled enlargements.
- Enlargement of entire screen or a specific part of it.
- Colour changes.
- Changes in mouse pointer size or colour.
- Attachment of a "localizer" to the cursor.

In addition, the magnifiers now available have a speech synthesis feature for greater user convenience, which, in addition to enlarging objects, emits voice messages that help users interact more readily with their computers.

An understanding of the basic operation of screen magnifiers is needed to develop software to be used with them, since certain details must be addressed in the design of such applications.

There are several presently on the market, made by different manufacturers, although the most popular are Ai2's ZoomText (http://www.aisquared.com) and Freedom Scientifics' Magic (http://www.freedomscientific.com).

Screen readers

This type of software, which sends the information on the screen to an output device -a speech synthesizer, a Braille display or both-, are designed for users with visual impairments.

They also enable users to operate the computer with a series of keyboard commands and combinations.

In other words, they provide for mouse-free, keyboard-command operation of most software functionalities, and at the same time keep users continually informed of the actions performed.

Screen readers use information from the operating system and the objects displayed on the screen at any given time; therefore, the higher the degree of standardization of an application, the easier it will be to use with the aid of such software.

Several screen readers of different makes are available on the market, although the most widely used is Freedom Scientifics' (http://www.freedomscientific.com) JAWS.

ANNEX 2

Notes for raised printing

This annex discusses the fuser sheets used with touch or digitizing screens.

Fuser technology uses a special kind of paper, called swell or microcapsule paper, which **raises** the lines or patterns printed on it when exposed to a source of heat (fuser heater). This converts printed data into tactile information accessible for users with visual impairments. The sheet containing the raised print is then placed on a digitizing pad for exploration and interaction with an optical pencil.

It must be stressed here that drawings displayed on the screen are not, generally speaking, acceptable for fuser printing, either because of their complexity (they tend to contain too much information) or the use of very fine lines (that the fuser is unable to raise). Therefore, an adapted file must be developed and attached to print such objects on swell paper or with a Braille embosser.

Another important consideration is that the information displayed on the screen and intended for users to access by touch should be delimited in some way to help them understand what is printed on the page and shorten their exploration time, which is always longer than needed by a person with normal vision.

A few helpful hints in connection with these files:

- The background for images to be printed on swell paper must be white so fill and outlines stand out for tactile perception. The fuser raises dark backgrounds along with the overlaid objects, defeating the entire purpose of this type of printing.

- Simplify drawings. If actual drawings cannot be simplified or replaced by their name, simple designs may be used instead; the aim is for students to see that there is something on the screen which, when touched, emits a sound (to relate an animal to the sound it makes, for instance, the drawing might be replaced with a regularly or an irregularly shaped object).

- Sometimes drawings can be replaced with their respective names in Braille.

Since this will often entail problems of space, the first few letters of the word may be written on the screen and the full name verbalized when the respective order is executed. This would be the solution of choice, for instance, in activities involving animals or objects very difficult or impossible to adapt, either because of the complexity of the drawing or the lack of space.

- Do not overlay objects.

- Elements on swell paper should be neither too small nor overly large (scaled to the size of a child's hand, for instance, depending on the age of the user).

- If the various printouts contain text, it should be transcribed to Braille for printing on swell paper.

- Outlines should be thick. The main outline should be the thickest solid line (6 points), followed by secondary lines (3 points) direction (reference) lines, (1.5 points).

  In addition to thickness, line style may be varied, using dots, dashes zigzags and so on. The main line must, however, always be solid and thicker than any other. Figures should not contain too many lines: an excess of information is detrimental.

- If parallel lines are drawn too close together, they may be mistaken for a single line.

- Where lines cross, the ones of lesser importance should be interrupted and the more important one continued.

- Dots and/or lines may be used as fill patterns. If text is to be included, it must be clearly differentiated, i.e., with a white border to make letters readily distinguishable.

  Figures should not contain too many different fill styles or patterns: an excess of information is detrimental.

  The most important figures should be the most highly textured. If patterns have some meaning, an explanatory legend must be included on the same page. For instance, where various areas of a map are textured differently, a legend must be provided relating each texture to its meaning.

By way of example, the following patterns are available in the MS word processor, Word:

Spaces may be lettered or numbered rather than textured, and a same-page legend formulated accordingly.

- All swell paper printouts must contain the title in Braille for user reference, in case the pages are dropped or misplaced.
- Objects repeated on different screens or pages should always be treated in the same way throughout the application.
- Patterns and lines should be limited to a total of six levels for readier comprehension.
- Objects should be drawn to scale as far as reasonable: an elephant should be larger than a dog, for instance.
- Perspective should not be used.

A few hints are also in order for Braille embossers:

- Texts must be correctly printed: with prefixes for capital letters, numbers, accents and so on.
- Activities designed to teach children to read must be printed in Braille; children must, after all, learn to read by touch, not by ear.
- Where students are expected to interact with Braille texts, the printout should correspond to the screen focus; the fuser method is very likely the more suitable option in such cases.
- If the application contains long texts, they must be printable in Braille so they can be read by users.

ANNEX 3

Perception in children with visual impairments

For a better understanding of what children with visual impairments can or cannot do with a computer and how content should be presented to make it accessible for them, developers should be familiar with certain basic ideas about such children's perception and the implications of sightlessness for the learning process.

Perception in children with visual impairment

In chapter 2 of the book titled **Puentes invisibles**, published by ONCE in 2003, authors Rosa Lucerga Revuelta and Mª Jesús Sanz Andrés discuss the perceptive-cognitive aspects of a visually impaired baby's development and the chief obstacles deriving from the lack of sight.

> *"Sighted subjects perceive reality as a continuum, outside themselves. In other words, sight allows subjects to observe and congruently organize the time sequence of events in the outside world and make sense of them. The difficulty typically experienced by sightless children to perceive their surroundings continuously and simultaneously interferes to a greater or lesser extent with their development."*

Of the specific developmental shortcomings affected by the foregoing, according to these authors, the ones impacting the use of new technologies most directly are:

- "Consistent integration and interpretation of part of the information received from outside. The visual image of an object, a feeding bottle, for instance, is the material medium to which babies relate a whole series of sensations: colour, form, taste, tepidity or odour revolve around a concrete visual image. A blind baby, however, may perceive the taste of milk and not associate it with the form or texture of the bottle containing it."

  If children who cannot see are not taught to integrate object stimuli through a diversity of experience, their understanding of many things will be only partial.

They may, therefore, be introduced to things on the computer that make no real sense to them and that need to be described or identified with some further information to make them recognizable.

- "Understanding causality. Difficulty to establish cause-effect relationships. Blind children often need help to relate the effect of an action to what caused it."

  Consequently, it will be difficult for them to understand, at an early age, why the computer makes one sound or another when they touch different keys on the keyboard. This difficulty can be overcome, however, with practice and adult mentoring, so in just a few sessions children acquire the ability to associate cause and effect, and are motivated to go on learning.

- "Understanding certain spatial-temporal structures. Difficulty to internalize schemes and spatial relationships and assimilate and anticipate time sequences. Blindness conditions spatial organization both as respects the ability to configure a space-scenario in which everyday events occur and to internalize spatial relationships such as inside-outside, up-down and so on. And, as discussed above, this constitutes a hurdle to ordering events in a congruent time sequence."

  This is not to say that visually impaired children fail to acquire such abilities, but simply that it takes them more time and effort. Activities must, then, be well explained and, at the earliest ages, highly simplified to prevent children from misunderstanding or being overwhelmed by the difficulty of the task in question. Besides, spatial concepts, when transferred to two-dimensional space, are related in ways that have little to do with the reality perceived by blind children, since they are created on the basis of visual codes. For instance, the "up" of the sky and the "down" of the ground actually mean, for a blind child confronted with a piece of paper on his/her desk, "near to or far from my body". It takes more explanation and experimentation for such children to understand up/down. Similar difficulties arise around images in perspective on a computer screen used to teach notions such as inside/outside, near/far… so authors must enlist their creativity to help blind children understand things that for others are obvious, clear and intuitive.

Moreover, computers can be used as a tool to deal with spatial concepts that may be difficult for blind children to assimilate, and can be highly motivating when programs are accessible and different access peripherals are used (joystick, concept keyboards…).

- “Contrasting many phenomena with reality itself (proof of reality). Deprivation of the perceptive evidence afforded by sight. Evidence of this impediment to discover on their own things that are obvious to sighted children arises in any number of situations. It is not uncommon for blind children not to realize that they are in the same room as their parents, for instance, or not to know where they themselves are, even when not in an unfamiliar place."

  When working with a computer application, therefore, children with visual impairments may not know where they are or be unaware of a presence that for everyone else is obvious (e.g., the character guiding the application except when it is talking).

- “Control of the environment. Difficulty or inability to learn and perform skills geared to acquiring a command of their surroundings. Many types of behaviour are very difficult for blind children and some utterly impossible without the support of someone who plays the role of their “auxiliary self”. Tasks involving hand-eye co-ordination such as cutting or painting are particularly difficult.”

  The games or exercises in certain applications should be recommended for group play or be conducted with specific help due to this difficulty.

- “Experience-based understanding of a number of domains of reality. Difficulty to perceive and acquire experience with large or distant objects or dynamic realities inaccessible to tactile perception. Consider, for instance, objects such as a train, a building, animals other than pets, the sky… The notion of movement is difficult to understand through tactile exploration, since when the child touches something in motion, it stops. Consider, for instance, the movement of a ball through a maze or an object falling from the desk to the floor.”

The applications used may contain images representing notions with which the child has only limited experience and which will have not only to be described, but explained and associated with sounds denoting movement towards or away from the subject…

In addition to the foregoing, account must also be taken of certain differences between visual and tactile perception and the respective consequences for the way material is introduced to the child:

- Sight is involuntary, while touch is a conscious act that must be willed by the subject. Hearing, like sight, is involuntary; but the content provided by hearing is limited and, if several sounds are combined, the information gathered may be distorted beyond recognition.

- There is a huge difference between the tactile and visual interpretation of drawings, graphs, tables… and that difference grows with the degree of detail. Simple images with clear geometric shapes and the distinctive features (elephant's trunk, duck's beak..) of the objects clearly outlined, are easier to interpret.

- Not everything that can be perceived by sight needs to be transferred to tactile form. This means that a selection must be made to ensure that printable images or exercises include only elements that provide rather than distort information; and this also applies to any oral descriptions of images.

- Visual shapes in drawings cannot always be associated with tactile forms. Many visual images are merely invented codes universally accepted by the sighted, but with no meaning for people with visual impairments.

  One example would be a drawing of a house: for blind children this is nothing more than a square with a triangle on top and smaller squares or rectangles inside; their experience with houses has nothing to do with such a drawing, since they are neither able to see houses as a whole nor are they accustomed to seeing them drawn the way other children are. And yet blind children can and must learn to interpret these schematic drawings.

One possible approach to teaching such notions is by giving and oral explanation of how things are represented while allowing the child to handle three-dimensional objects and mock-ups that mimic reality and enable him/her to form an overall idea of the concept represented in the drawing (a toy car, a mock-up of a house...).

Perception in children with severe visual impairments

Children with severe visual impairments may suffer from any of a wide variety of pathologies which affect the way they see in many different ways; and there may be individual differences even within a given pathology. Two children diagnosed for the same disorder may in fact use their vision differently. Nonetheless, certain general problems can be identified depending on the visual trait affected in each case:

- Problems deriving from the lack of visual acuity. Visual acuity is the ability to clearly perceive details. When impaired it may hinder the interpretation of small symbols, contrast perception, distance vision (teacher's screen, blackboard…) or visual adjustment from the screen to keyboard and vice-versa; or it may generate a need for specific lighting or distort the subject's perception of reality…

- Problems deriving from a limited field of vision: visual field is everything encompassed by sight regardless of the viewer's vantage. Any number of pathologies affect visual field, although to simplify they can be divided into peripheral and central field pathologies. In the former, the subject's peripheral vision is affected, irrespective or his/her ability to distinguish detail; in other words, children with such pathologies see only part of the screen, precisely where they direct their gaze. They thus find it difficult to see whole elements or symbols if on a large scale, interpret scenes, particularly where movement is involved, or locate elements on the screen; and this difficulty affects the time it takes them to perform tasks. When their pathology affects central vision, the children involved can see parts of the screen, but not the part they are looking at. This, in addition to the above limitations, impacts their visual acuity.

- Problems affecting oculomotor control. These pathologies hinder hand-eye co-ordination, fixation, change in focus from screen to keyboard…

Other circumstances to bear in mind in connection with computer use

- From a very early age, sighted children become familiar with computers as a household appliance, a device used in stores, a classroom tool… Blind children, however, are completely oblivious to their existence unless an adult expressly shows them one or if they are given the opportunity to move about freely and touch anything they find within reach. They must, then, first be allowed to get to know the computer and its components as “objects”, to run their hands over it, to listen to how it sounds when turned on and off…

- It takes children with visual impairments more effort than their sighted peers to learn to use computers, although once they acquire that skill, it opens doors unthinkable even in the relatively recent past. They have to operate with their hands and ears only, use keys to find things that others can see on the screen, sometimes use one hand for tactile perception while performing a task with the other…, all of which spells greater effort. Ways must be found, therefore, to simplify program operation and make software more attractive to the ear and, as appropriate, the touch, through concept keyboards, embossers or supplementary materials for certain exercises. This makes the computer a useful and motivating tool for blind or visually impaired children, while enhancing their attention span, learning aptitudes and communications skills.

- They generally have a slower learning pace and it takes them longer to perform tasks than most sighted children. What sighted children learn intuitively calls for a conscious effort on the part of the blind or visually impaired, who must memorize the use of keys, commands… And in the absence of visual imitation, they find it more difficult to copy the teacher’s model or to follow instructions on a large screen.

- Educators and classroom teachers also find it more difficult to teach children with visual impairments, so programs must be easy for both teacher and pupil to operate. Furthermore, when very young, these children will be more dependent upon adults during the learning process.