InSIDE: Including Students with Impairments in Distance Education

Delivery DEV2.1	Development of educational materials

Authors	Eleni Koustriava[1], Konstantinos Papadopoulos[1], Konstantinos Charitakis[1]
Partner	University of Macedonia (UOM)[1], Johannes Kepler University (JKU)
Work Package	WP2: Adapted educational material
Issue Date	31-05-2020
Report Status	Final

Project Partners

University of Macedonia, Greece *Coordinator*	**National and Kapodistrian University of Athens, Greece**
Johannes Kepler University, Austria	**University of Aboubekr Belkaid Tlemcen, Algeria**
Blida 2 University, Algeria	**Mouloud Mammeri University of Tizi-Ouzou, Algeria**
Ibn Tofail university, Morocco	**University of Sciences and Technology of Oran Mohamed Boudiaf, Algeria**
Cadi Ayyad University, Morocco	**University of Sfax, Tunisia**
Abdelmalek Essaadi University, Morocco	**University of Tunis El Manar, Tunisia**
University of Mohammed V in Rabat, Morocco	**University of Sousse, Tunisia**

Project Information

Project Number	598763-EPP-1-2018-1-EL-EPPKA2-CBHE-JP
Grant Agreement Number	2018-3218 /001-001
Action code	CBHE-JP
Project Acronym	InSIDE
Project Title	Including Students with Impairments in Distance Education
Funding Scheme	Erasmus+ KA2
Date of EC approval	13/12/2018

Contacts	Assistant Professor Eleni Koustriava
Address	University of Macedonia, Thessaloniki, Greece
Phone	+30 2310891333
eMail	elkous@uom.edu.gr
Project Website	www.inside-project.org

Document Information

Title	Delivery 2.1 Development of educational materials
Issue Date	31/05/2020
Deliverable Number	2.1
Work Package	WP2: Adapted educational material
Task Number	2.1
Activity number	2.1.1, 2.1.2, 2.1.3 & 2.1.4
Partner Responsible	University of Macedonia (UOM)
Partners involved	UOM, JKU
Status	Final
Dissemination Level	PU • **PU** Public • **PP** Restricted to other programme participants (including the Commission Services) • **RE** Restricted to a group specified by the consortium (including the Commission Services) • **CO** Confidential, only for members of the consortium (including the Commission Services)

Contents

Abbreviations

Acronym	Term
HE	Higher education
HEI	Higher education institution
HI	Hearing impairment
HTML	Hypertext Markup Language
ICT	Information and communications technology
InSIDE	Including Students with Impairments in Distance Education
IwI	Individual with impairments
JKU	Johannes Kepler University
LMD	Licence, Master, and Doctorate
MI	Mobility impairment
MOOCS	Massive Open Online Courses
PDF	Portable Document Format
SVG	Scalable Vector Graphics
TSS	Tiger Software Suite
UABT	University of Aboubekr Belkaid Tlemcen
UAE	Abdelmalek Essaadi University
UB2LA	Blida 2 University
UCA	Cadi Ayyad University
UIT	Ibn Tofail University
UM5R	University of Mohammed V in Rabat
UMMTO	Mouloud Mammeri University of Tizi-Ouzou
UOA	National and Kapodistrian University of Athens
UOM	University of Macedonia
US	University of Sousse
USFAX	University of Sfax
USTO	University of Sciences and Technology of Oran Mohamed Boudiaf
UTM	University of Tunis El Manar
UD	Universal design
UDL	Universal Design for Learning
ViHeMo	Visual, hearing, mobility/physical
VI	Visual impairment

Acronym	Term
W3C	World Wide Web Consortium
WCAG	Web Content Accessibility Guidelines
WP	Work Package

About InSIDE

The aim of the project is to develop accessible DE programmes for individuals with ViHeMo impairments. The concrete aims are to: a) develop an accessible, inclusive and educationally effective model of DE that will deliver key competences for vocational rehabilitation, and provide opportunities for lifelong learning, skills enhancement, and personal fulfilment with the ultimate aim of suggesting an intelligent solution against the problems of limited access or high percentage of dropouts in HE in IwI, b) structure a strong cooperation between organisations with sound expertise in accessible and inclusive HE and organisations where both the modernisation of HE and the promotion of the right to education of IwI is imperative, and c) widen the horizons of local HE towards an international and intercultural education through DE programmes.

The overall objectives of the project are to:

1) Develop new and innovative, accessible and inclusive DE programmes improving the quality of HE for individuals with ViHeMo impairments and offering flexible learning and virtual mobility
2) Upgrade the facilities through establishing accessibility offices and acquiring assistive technology resulting in modernization of university services
3) Build capacity and professional development in administrative and teaching staff in developing and carrying out accessible and inclusive DE programmes, and operating the accessibility offices
4) Involve individuals with ViHeMo impairments in a user-center design so that accessibility and usability are achieved in conjunction, and the links between education and society are strengthened

The specific objectives of the project are:

• The preparation of the development stage through an extended literature review for precedent trials in DE for IwI
• The development of the most suitable educational material for IwI (ViHeMo) in terms of accessibility, usability and educational efficacy through the study of end-user requirements
• The adaptation of a course delivery system that best serves the needs of IwI (ViHeMo) in DE
• The foundation of accessibility services in HE so that SwI would be supported during their attendance in HE
• The training of advisors in the services of the accessibility offices, and the training of the trainers (advisors and representatives) so that they will be able to train the end-users (teaching staff and IwI)
• The examination of the regular co-operation of all the above to deliver inclusive DE courses effectively when learning and skill enhancement are concerned, considering end-users feedback too
• The dissemination and exploitation of the project deliverables on an international level.

1. Introduction

The present report presents the objectivesm description and the development procedures based on which the educational material in a preliminary version will be developed in order to meet the needs of students with impairments. The following sections present representative samples of all the different types of information output both in printed and in digital form developed: a) text (simple text, table, mathematical representation), c) audio, d) graphics (image, diagram, digital design), e) multimedia (presentation, video, 3D graphics/video), f) tactile (model).

2. Objectives, Description and Development Procedures concerning adapted educational materials

2.1. Description of the specific needs of students in each category of impairments – visual, hearing and mobility/physical impairments

Objective

The identification of important sources of information on the needs of students with ViHeMo. impairments. This information will form the basis for the design and development of educational material in a preliminary version.

Description

The literature was reviewed in a systematic way. Several databases were retrieved (e.g. Research gate, ERIC, Elsevier) as dominant resource. Also, university websites were sought as important sources of information on the needs of students with impairments.

2.1.1. Specific needs of students with visual impairment in higher education

The use of the web has extremely risen among Higher Education Institutions (HEIs). As most HEIs have websites in order to provide information, access and services for students, the demand for website accessibility in HEIs is increasing. If websites are not designed to be technically accessible, students with disabilities, such as visual impairment (VI), are being excluded (Agangiba & Agangiba, 2019) from education process. According to the findings of Agangiba and Agangiba (2019), none of HEIs' websites examined in Ghana comply with the acceptable web accessibility level of compliance, thus students with VI would have difficulty in accessing them. Students with Visual Impairments (VI) have more difficulties in accessing websites than others with other disabilities, because of the extensive use of visuals in websites (Menzi-Cetin, Alemdag, Tuzun & Yildiz, 2017).

The Web Content Accessibility Guidelines (WCAG) provides principles of Web accessibility established by the World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI) in 1999 (Babu, Singh & Ganesh, 2010). International guidelines or standards that check websites in regard to usability and accessibility are important (Menzi-Cetin et al., 2017). Literature analysis shows that although WCAG is essential, it is not adequate for the evaluation of Web accessibility for individuals

with VI (Babu, et al., 2010). The respective specific guidelines of WCAG 2.0 for individuals with VI [World Wide Web Consortium (W3C), 2008] are the following:

- Guideline 1.1 Text alternative: Provide text alternatives to other forms such as large print, braille, speech. For example, an individual with VI can have the text alternative read aloud through the use of synthesized speech.
- Guideline 1.2 Time-based media: Provide alternatives for time-based media (audio description or media alternative of the video content).
- Guideline 1.4 Distinguishable: Make it easier for users to see and hear content including separating foreground from background. Individuals with VI have greater difficulty in separating foreground from background information. Examples of success criteria for this guideline are: use of color, contrast, resize text.
- Guideline 2.2 Enough time: Provide users enough time to read and use content. Individuals with VI take longer to read or find things.
- Guideline 2.4 Navigable: Provide ways to help users navigate, find content and determine where they are. Explain what provisions are needed in order screen reader users to successfully navigate the content.

Except for WCAG 2.0 guidelines, there are also other accessibility guidelines such as the International Organization for Standardization (ISO). According to ISO/IEC GUIDE (2014), some design considerations that can facilitate accessibility for Individuals with VI are: multiple means of information presentation, avoidance of glare, suitable size, form, contrast, luminance, lighting and viewing distance concerning the context of use, suitable physical construction and properties of fonts such as size, spacing, with or without serif.

The study of Menzi-Cetin et al. (2017), in which the usability of a university website for students with VI was assessed, comes to conclusion that a support center for assisting those students to enroll in courses and to overcome other challenges could be created in the university. The creation of support services is also mentioned by. Moh (2012). Ringlaben, Bray and Packard (2013) evaluated the accessibility of websites of university departments of special education. Their findings indicate that the majority of the web pages assessed (97%) have accessibility problems. Online accessibility checkers, such as ATRC Web Accessibility checker (CIE), should be used to provide information regarding accessibility problems (Ringlaben et al., 2013).

The adoption of online learning (or else Learning Management Systems) by academic institutions continues to expand around the globe (Murray, Perez, Geist & Hedrick, 2012). Student registration in online courses is increasing more and more, making the development in distance education a worldwide phenomenon (Murray et al., 2012). It is worth mentioning that the study of Koustriava and Papadopoulos (2014) found that individuals with VI have a slightly can-do attitude towards distance learning. E-learning can be an important opportunity for users with VI, if appropriate teaching methods and technologies are used (Kharade & Peese, 2012). It is essential to recognize the needs and requirements of the target population so as to create a system that lives up to their expectations (Kharade & Peese, 2012). Completing e-learning tasks becomes difficult for students with VI (Babu, Singh & Ganesh, 2010), as the design of e-learning courses is inaccessible to them (Armstrong, 2009). Teaching environments and e-learning materials are mainly vision-centric, including images, animation, and hence those students do not have equal opportunity to obtain tertiary skills pertinent to the marketplace (Armstrong, 2009).

In terms of e-learning material, students with VI do not have access to some course notes and materials, including those in PDF, they experience technical difficulties while using e-learning and connecting to websites, they have problems downloading and opening electronic files and difficulties

with web pages that would not load (Fichten, Asuncion, Barile, Ferraro & Wolforth, 2009). Given that the use of information and communication technologies on campus and in distance education is widespread, it is important the improvement of accessibility of e-learning material with the adoption of universal instructional design and the provision of needed technology and training to students with VI (Fichten et al., 2009). Instructional designers need to be aware of the different needs of totally blind students, students with low vision and sighted students (Armstrong, 2009). For instance, blind students deal more problems with e-learning materials than students with low vision (Fichten et al., 2009).

The challenges that students with VI encounter within higher education reveal the specific needs (which are not taken care of by higher education) of those students. Some e-learning challenges faced by students with VI are: timed graded activities, colour contrast, email, videos, graphics, navigation, formats of the course material, technical support (Kharade & Peese, 2012). Some of the suggestions given by students with VI are the following: timed assessments only when necessary and even then should be provided extended time, instructors should avoid posting PDF files and instead use Microsoft Word documents, they should be trained to deal with the online learning challenges of users with VI, online learning designers should use proper headings, accessible graphics, fewer frames, contrasting colours, accessible formats of materials (Kharade & Peese, 2012).

While using e-learning systems in higher education, students with VI meet problems of availability (e.g. Braille books, audiobooks, screen reading software such as JAWS, NVDA are available for English but not other regional languages, lack of facility to understand pictures, diagrams, graphs), problems of affordability (e.g. expensive original software such as screen readers, anti-virus software and assistive technology), problems of accessibility (e.g. dearth of specially designed accessible websites, problems of the internet connectivity), problems of efficacy (e.g. slowing down the system, lack of voice clarity), problems of sufficiency (e.g. lack of specially designed e-learning sources) and problems of utility (e.g. scanned documents are needed to be edited, problems in reading graphs, pictures by using PowerPoint) (Gill, Sharma & Gupta, 2017). Many suggestions are made to overcome the above problems and respond to the needs of students with VI (Gill et al., 2017). For example, screen readers should read all the languages, every photo should have a caption, software should have fast speed and easy access, all the websites should be accessible, e-systems should follow WC3 web content guidelines, training for e-learning should be provided (Gill et al., 2017).

In an e-learning setting, instructors should adopt student-oriented interactions with students with VI, ensure feasible communication methods, provide the syllabus beforehand, along with accessible digital textbooks, alternative assignments, time extension (Oh & Lee, 2016). Interaction with the instructor resolve issues related to course-related information, adjustment to e-learning, counseling, special services which are suitable for students with VI (Oh & Lee, 2016). The encouragement of students with VI to persist with e-learning depends not only on the interaction with the instructor, but also on the interaction with other students and the course content as well (Oh & Lee, 2016). Students with VI find online interaction with other students difficult because of the inaccessibility of a web-based education environment (Oh & Lee, 2016). Therefore, what is needed is, primarily, to reinforce web-accessible communication regulations (Oh & Lee, 2016). Another recommendation is to urge classmates without visual impairment to use voice messages and large fonts when they communicate with students with VI (Oh & Lee, 2016). In terms of the interaction with the course content, it is suggested the use of Digital Accessible Information System (DAISY) and generally, the design of accessible web content in response to the needs of those students (Oh & Lee, 2016).

The major part of web-based content is not designed for assistive technologies. Commonly used assistive technologies (Braille display devices, screen reading software, screen enlargement software)

cannot translate graphical images. Although research in the development of assistive technologies is regularly presented in the literature, the development of other sophisticated technologies, such as haptic, force-feedback, are still in their infancy. HEIs need to adopt multi-modal user interfaces, making e-learning materials more accessible to all students (Armstrong, 2009).

A major challenge of academic students with VI is the lack of assistive technologies for accessing the web (Madumere, Mbajiorgu & Uwakwe, 2019). The use of suitable assistive technologies for academic libraries should be obligatory in order to meet the information needs of students with VI (Tripathi & Shukla, 2014). The latter need specific assistive technologies, such as computer technologies (screen readers, screen magnifiers), tactile tools (Braille books, large printed materials, Braille translation software) and auditory tools, to satisfy their need for information and knowledge (Abdelrahman, 2016).

It is recommended that libraries create assistive technology centers, including computer laboratory and talking book studio (Tripathi & Shukla, 2014). Tripathi and Shukla (2014) refer and explain that in the computer laboratory, the computers should be equipped with the following software:

- Enlarging or Magnifying Software, such as Zoom Text from AI Squared, Dolphin's Lunar and Super Nova, Magic from Freedom Scientific. It allows students with VI to read email, carry out other text-based tasks, adjust the size of the text and change attributes.
- Screen Reading Software, such as Windows Eyes from GW Micro, JAWS from Freedom Scientific. It scans text and reads it aloud with the use of speech synthesizer.
- Kurzweil 1000 - It scans and reads software, making printed or electronic text accessible.
- Talking Typing Pro - It helps users with VI to learn and practice keyboard skills.
- Math scanning and reading software, such as Infty Reader and Picture in a Flash (PIAF) Tactile Graphic Maker.
- Tactile Drawing Boards - For example, Draftsman Tactile Drawing board which creates instant raised-line drawings.
- Tactipad Drawing Tablet - It allows the creation of tactile images.
- Math Window - It makes easier the understanding of math concepts.
- Tactile Graphic Image Library.
- Graphic Aid for Mathematics - It constructs geometric figures and graphs.
- JAWS Talking Software for the Blind - It converts a normal computer into a talking computer to enable a person with VI to use the computer independently.
- VP Arithmetic - It allows individuals with VI to work on Algebraic functions like fractions, square root.
- Scientific Calculator with Speech - It enables the user to perform statistical, scientific and trigonometric calculations and fractions.
- Scientific Calculator for Low Vision - It enables the user to perform statistical, scientific and trigonometric calculations and fractions.
- Geometric Set in Braille - It is useful for individuals with VI engaged in learning, geometry, engineering or mathematics.

The review of the literature shows that library services do not satisfy the information needs of the students with VI in higher education and do not provide assistive technology to enable those students in accessing library resources (Dodamani & Dodamani, 2018). Although students with VI have the same information needs as that of sighted, digital information services are not available for them (Zia & Fatima, 2011). Zia and Fatima (2011) investigate the digital information needs of the students with VI studying in the University of Karachi. Based on the findings of their study, some measures are proposed:

- The website of the library should provide information in the form of text to speech.
- Software and hardware specially designed for students with VI should be provided. For example, computers with Braille keyboard, computers equipped with speaker or headphone Braille mouse, close circuit screen display and Braille printers.
- Training of Braille computer literacy for students with VI.
- Braille conversion of the information material should be available on the website of the digital library. It should be Braille print friendly as well.
- Internet connectivity should be provided in each faculty of the university.
- Staff assistant should be provided for users with VI.

Although the assistive technology in university libraries, the accessibility of library website, the private study rooms in library, the availability of e-resources in accessible format are important services for students with VI, ensuring their equitable access to the resources and services of university libraries, the majority of the academic libraries in India does not provide such services for the benefit of people with VI (Dodamani & Dodamani, 2019). Library services available worldwide for students with VI are insufficient (Abdelrahman, 2016). It is obvious the lack of library and technological equipment concerning the number of students with VI at the university of Khartoum in Sudan (Abdelrahman, 2016). There is also a shortage of access to services in Tanzanian academic libraries for students with VI and in mobility impairment (Majinge & Stilwell, 2013). Students with VI need to have access to resources and services of university libraries (Madumere et al., 2019).

Library's websites inaccessibility, attitude of library staff, a dearth of research, resources and training facilities have been recognized as obstacles in delivering accessible services to students with VI (Bhardwaj, 2018). The lack of accessible materials in Nigerian academic libraries leads students with VI to marginalization. Therefore, there is a necessity to ensure an equitable library and information services for those students (Babalola & Haliso, 2011). The libraries should sign up for Daisy consortium and Book Share, providing in that way unlimited access to reading materials for people with VI (Tripathi & Shukla, 2014). According to the statements of students with VI, the preferred format of reading material in libraries for them is the reading of digital text (Papadopoulos & Koutsoklenis, 2009).

Otyola, Kibanja and Mugagga (2017) investigated the challenges faced by students with VI in Makerere and Kyambogo Universities. Their findings indicate the following challenges: social marginalization, lack of trained staff in special needs, insufficient equipment, lack of learning material, inadequate time for the exams. Strict time limits to finish activities that are part of online testing of course management systems constitute a problem for students with VI (Fichten et al, 2009a), a finding also noted by other study (e.g. Kamei-Hannan, 2008). Postsecondary students with VI need sufficient time so as print materials to be converted into accessible formats before the course begins (Ostrowski, 2016). Extra time to support the learning of students with VI is also mentioned on the study of Quirke, McCarthy and McGuckin (2018).

Lecturers find teaching students with VI as a burden, due to the fact that they are not trained to teach those students, and thus specialist lecturers who teach students with VI are needed (Mushome & Monobe, 2013). Limited support, inadequate material and specialist teachers, negative attitudes towards students with VI are problems faced by students with VI in the tertiary education of developing countries (Nhemachena, Kusangaya & Gwitira, 2012). Another obstacle faced by students with VI is the access to textbooks (Gilson, Dymond, Chadsey & Hsu, 2007; Moh, 2012).

Taking into consideration the needs of students with VI, higher institutions should provide qualified instructors, adequate information technology and library services, special educational facilities and devices (Omede, 2015), advanced ICT-based facilities, special training classes to enhance the

competency of students with VI in ICT application for learning purposes (Eligi & Mwantimwa, 2017), accessible (reading) material in alternative formats (e.g. braille, talking books, e-books) (Quirke et al., 2018; Tripathi & Shukla, 2014), accessible website of the academic library (Tripathi & Shukla, 2014; Zaid & Zaid, 2017), accessible digital platforms using the WAI-ARIA landmarks (which is a technical specification implemented by W3C in 2014) (Regec & Regec, 2016). Training for instructors and course designers, state-of-the-art assistive technology are essential for students with VI to obtain the support they require (Ostrowski, 2016). There is a need for an integrated approach for the inclusion of students with VI in the university, addressing the issue with the limited provision of social support (Papakonstantinou & Papadopoulos, 2016). The provision of psychological counseling services would be an important support for students with VI who have a high level of perceived stress and depressive symptoms (Lee & Oh, 2017).

2.1.2. Specific needs of students with hearing impairment in higher education

It is evident the dearth of research in the area of students with Hearing Impairments (HI) in higher education environment (Hureau, 2008).

There is almost no research that has examined the learning and teaching needs of students with HI in higher education in South Africa Although the curriculum for accessibility and inclusive teaching practices are important for students with HI, teaching practices are not inclusive at a South African university and the practices needed for those students, such as electronic notes and electronic calendars, are not provided either. In terms of the curriculum, it does not comply with the principles of accessibility, flexibility and thus it does not satisfy the demands of the students with HI. There is a profound need for increased learning support, such as academic one-to-one tutoring and real-time speech-to-text captioning (Bell & Swart, 2018).

Teaching strategies that can be used by professors to fulfill the expectations of students with HI include: repeat questions asked by students, speak clearly, use visual material (e.g. diagrams, key vocabulary, virtual learning environment), have a transcription of lecture notes or a note-taker to be present, point out when they are changing the subject, check comprehension and direct questions, use facial expression (University of Leicester, n.d.), use more than one way to explain information, describe clearly course requirements (dates of exams, deadline of assignments), give brief instructions, provide captioned videos, overheads and other visual aids which are beneficial instructional tools for students with HI, provide lectures handouts beforehand, give extra time for student with HI to assimilate information (Ferris State University, n.d.).

Students with HI make some suggestions concerning their learning needs (Bell & Swart, 2018): Lecturers should learn and adhere to the principles of universal design in their curriculum design, methods and chosen materials, they should keep abreast of how to provide suitable support for students with HI, ensure that they are cognizant of the (specific) needs of each student by collaborating with the disability support services, create glossaries of new and complicated terminology and provide electronic copies of notes far in advance to make possible pre-reading of materials, be available to meet with the students and "out-of-class" communicate with them by email, ensure that all audiovisual materials have subtitles.

University students with HI face communicational barriers (Levy & Ferreira, 2019). For example, social difficulty, improper behavior of classmates and professors, learning difficulty, struggle to understand classmates and professors and to accompany the content during classes (Levy & Ferreira, 2019). Furthermore, they do not have full access to information in university lectures and only

interpreting is not enough for providing them full access in educational settings (Napier, 2004). What students with HI in a higher education context need are real-time captioning services, hearing augmentation devices, alternative support systems (e.g. live remote captioning) (Brett, 2010), interpreting, notetakers (Brett, 2010; Cawthon, Nichols & Collier, 2009; Hyde, Punch, Power, Hartley, Brennan & Neale, 2009; Powell, Hyde & Punch, 2013), social-emotional support (Hyde et al, 2009), cultural understanding of their backgrounds by professors (Torres, 2019), provision of assistive technology (Cawthon et al., 2009; Smith & Andrews, 2015). The most prevailing types of support services for students with HI in tertiary education are: interpreting, tutoring, academic advising, real-time captioning (Lang, 2002). Support services necessary for students with HI could include: academic tutors, manual note-taking, real time captioning, extra time, instructional and curriculum adaptations, induction loop systems, language modification and assistive devices (e.g. vibrating alert devices, sonal FM systems) (Bell & Swart, 2018).

The provision of an accessibility center, as a part of university service, can facilitate students with HI, offering services such as organization of notetaking and interpreting services, contact with academic staff when appropriate, one to one support to talk about study issues or other practical matters, help with applications for the funding of specialist equipment (University of Leicester, n.d.).

The guide to follow in order to ensure the accessibility of online resources is WCAG 2.0. The specific guidelines for students with HI of the World Wide Web Consortium (W3C), (2008) are:

- Guideline 1.1 Text alternative: For example, a person with HI can have the text alternative displayed so that he or she can read the audio file. In the future, text alternatives will let the information translated into sign language.
- Guideline 1.2 Time-based media: Provide alternatives for time-based media (captions, audio description, sign language).
- Guideline 1.4 Distinguishable: Make it easier for users to see and hear content including separating foreground from background. People with HI have more difficulty in separating foreground from background information.

In addition to WCAG guidelines, there are several international organizations of standardization, such as the International Telecommunication Union (ITU) and the ISO, offering guidelines for providing accessible web material (Debevc, Kosec & Holzinger, 2011). ISO/GUIDE (2014) refers some design considerations to make the accessibility for people with HI easier: multiple means of information presentation (e.g. text, image), avoidance of unexpected changes in volume of auditory signals, communication systems (e.g. induction loops, infrared or radio systems), good acoustic of the environment. However, these guidelines are still too general, often insufficient and improper for the specific needs of users with HI who use sign language as their first language (Debevc et al., 2011). Those users need translations of the written text on websites that are written in their second language (Debevc et al., 2011). A need analysis presents that an important requirement of users with HI is sign language videos on websites (Debevc et al., 2011). The basic aspects of accessibility, regarding this analysis, have been divided into the following functionalities (Debevc et al., 2011): video control (pause and stop the video), video image resizing (increasing the size of videos), rapid display of the video, adding subtitles, slowing down the video, moving the video across the web page, use of sound for hard-of-hearing users.

E-learning systems are especially important for university students with HI as they have difficulty in attending the physical on-site learning programs (Nordin et al., 2015). Making e-learning systems available to people with HI consists a need for them to take advantage of this technology (Pappas et al., 2018). In order e-learning systems to be responsive to the needs of students with HI should include short learning modules, the educational content should have as little text as possible and

should be presented in a visual mode (e.g. images, videos with subtitles, sign language videos), should provide an automated assessment system (Pappas et al., 2018). In addition, the special needs of students with HI in an e-learning environment include: bilingual information (text and sign language), interactive and explorative learning, high level of visualization, learning in peer groups via video conferencing (Drigas, Kouremenos, Kouremenos & Vrettaros, 2005).

It is well-known that most e-learning environments for educational purpose are not accessible to university students with HI (Hashim, Tasir & Mohamad, 2013). It is of paramount importance to take into consideration the needs, usability and adaptability for the appropriate development of e-learning platform in order for students with HI to learn effectively (Hashim et al., 2013). Commonly used approaches for those students are video conference, video streaming, text adaptation, chat rooms, interactive and social tools (Hashim et al., 2013). Tapu, Mocanu and Zaharia (2017) propose a multimodal dynamic subtitle positioning system, specifically designed to increase the accessibility of people with HI to multimedia documents.

Besides the accessibility of websites, library professionals should provide electronic eBooks, articles, database platforms and instructional materials to users with various disabilities (Getts & Stewart, 2018). Literature that gives emphasis on providing e-library services to users with specific disabilities is insufficient and have a propensity to cover visual impairments and print disabilities more than any other type (Getts & Stewart, 2018). Specific suggestions to address the needs of students with HI in the distance education environment include: using accessible media players, implementing staff training on accessibility, captioning all library videos, using text alternatives (e.g. transcripts, captions) to make library audiovisual material more accessible, communicating with library staff through the use of electronic methods (e.g. email, chat, real-time-text) can be more accessible to students with HI than face-to-face services (Getts & Stewart, 2018).

2.1.3. Specific needs of students with mobility/physical impairment in higher education

As the number of students with disabilities in higher education has recently increased, their academic needs, specifically for assistive technology and educational services, need to be explored in assisting them to access learning activities (Lersilp & Lersilp, 2017). Students with Mobility Impairment (MI) are not sufficiently taken care of in the institutions of higher education (Lawal-Solarin, 2012). They need academic accommodations such as access to adaptive technology, assistive devices, advance books, reduced course load, extended time for tests and exams, attendant services (Niagara College Canada, n.d.), establishment of a disability office with educated staff concerning disability issues, campaign creation to raise awareness of disabilities (Hadjikakou Polycarpou & Hadjilia, 2010), the improvement of lecture's awareness in regard to the specific needs of student with MI (Hadjikakou et al., 2010; Keinen, 2018), counseling services, support groups, learning assistance, library assistive technologies (Ijadunola et al., 2018).

Assistive technology that is important for students with MI include: voice recognition software (e.g. dragon naturally speaking) which enable users to interact with technology by speaking to it as an alternative to using the keyboard and mouse input, adapted ergonomic keyboards which are specifically designed to reduce strains, twists, movements, tensions and so alleviate the pain and attempt of typing, mouse controls (e.g. trackerballs) which provide an alternative mouse input method, adapted furniture (AHEAD, n.d.), eye-tracking software which uses a user's eye movements

to control a computer interface like a traditional mouse, ability switches which offer an alternative means to interact with computers (BestColleges, n.d.).

2.1.4. References

Abdelrahman, O.H. (2016). Use of library technology and services by the visually – impaired and the blind in the university of Khartoum, Sudan. *DESIDOC Journal of Library & Information Technology, 36* (2), 93-97.

AHEAD (n.d.). Assistive technology. Retrieved from https://www.ahead.ie/assistivetech-students

Agangiba, M., & Agangiba, W. A. (2019). Evaluation of accessibility for the visually Impaired- The case of higher education institutions' websites in Ghana. *Ghana Journal of Technology, 3* (2), 58 - 64.

Armstrong, H. L. (2009). Advanced IT education for the vision impaired via e-learning. *Journal of Information Technology Education: Research, 8*, 243-257.

Babalola, Y. T., & Haliso, Y. (2011). Library and information services to the visually impaired-The role of academic libraries. *Canadian Social Science, 7* (1), 140-147.

Babu, R., Singh, R., & Ganesh, J. (2010). Understanding blind users' web accessibility and usability problems. *AIS Transactions on Human Computer Interaction, 2* (3), 78-91.

Bell, D., & Swart, E. (2018). Learning experiences of students who are hard of hearing in higher education: Case study of a South African university. *Social Inclusion, 6* (4), 137–148.

BestColleges (n.d.). College guide for students with physical disabilities. Retrieved from

https://www.bestcolleges.com/resources/college-planning-with-physical-disabilities/

Bhardwaj, R. K. (2018). Information access mechanism for visually impaired students in higher educational institutions: A Study. *Journal of Library & Information Technology, 38* (6), 387-395.

Brett, M. (2010). Challenges in managing disability in higher education, illustrated by support strategies for deaf and hard of hearing students. *The Open Rehabilitation Journal, 3* (2), 4-8.

Cawthon, S. W., Nichols, S. K., & Collier, M. (2009). Facilitating access: What information do Texas postsecondary institutions provide on accommodations and services for students who are deaf or hard of hearing? *American Annals of the Deaf, 153* (5), 450–460.

Debevc, M., Kosec, P., & Holzinger, A. (2011). Improving multimodal web accessibility for deaf people: sign language interpreter module. *Multimedia Tools and Applications, 54* (1), 181-199.

Dodamani, A., & Dodamani, S. (2018). Library services for the people with visual impairment in higher education: A review of literature. *Library Progress (International), 38* (1), 123-128.

Dodamani, A. M., & Dodamani, S. M. (2019). Provision of assistive technology for Students with Visual Impairment in University Libraries in India. *Journal of Library & Information Technology, 39* (3), 104-108.

Drigas, A. S., Kouremenos, D., Kouremenos, S., & Vrettaros, J. (2005). *An e-learning System for the deaf people*. In 6th International Conference on Information Technology Based Higher Education

and TrainingTHET 6th Annual International Conference. Retrieved from: https://ieeexplore.ieee.org/document/1560236

Eligi, I., & Mwantimwa, K. (2017). ICT accessibility and usability to support learning of visually-impaired students in Tanzania. *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 13* (2), 87-102.

Ferris State University (n.d.). *Teaching Strategies for Hearing Impaired Students*. Retrieved from https://www.ferris.edu/RSS/disability/faculty-staff/classroom-issues/hearing/hearing-strategy.htm

Fichten, C. S., Asuncion, J. V., Barile, M., Ferraro, V., & Wolforth, J. (2009). Accessibility of e-learning and computer and information technologies for students with visual impairments in postsecondary education. *Journal of Visual Impairment & Blindness, 103* (9), 543-557.

Getts, E., & Stewart, K. (2018). Accessibility of distance library services for deaf and hard of hearing users. *Reference Services Review, 46* (9).

Gill, K., Sharma, R., & Gupta, R. (2017). Empowering visually impaired students through E-Learning at higher education: Problems and solutions. *Journal of Humanities And Social Science, 22* (8), 27-35.

Gilson, C. L., Dymond, S. K., Chadsey, J. G., Hsu, S. Y. F. (2007). Gaining access to textbooks for postsecondary students with visual impairments. *Journal of Postsecondary Education and Disability*, 20 (1), 28-39.

Hadjikakou K, Polycarpou V, & Hadjilia, A. (2010). The experiences of students with mobility disabilities in Cypriot higher education institutions: listening to their voices. *International Journal of Disability, Development and Education, 57* (4), 403–426.

Hashim, H., Tasir, Z., & Mohamad, S. K. (2013). E-learning environment for hearing impaired students. *The Turkish Online Journal of Educational Technology, 12* (4), 67-70.

Hureau, M. S. (2008). Public Speaking Courses and the Hearing-Impaired College Student: Classroom Communication, Challenges and Rewards. *Online submission*, 1-29.

Hyde, M., Punch, R., Power, D., Hartley, J., Brennan, L., Neale, J. (2009). The experiences of deaf and hard of hearing students at a Queensland university: 1985-2005. *Higher Education Research and Development, 28* (1), 85-98.

ISO/IEC (2014). Guide for addressing accessibility in Standards (Edition 2).

Ijadunola, M.Y., Ojo, T. O., Akintan, F. O.,Adeyemo, A. O., Afolayan, A. S., & Akanji , O. G. (2018): Engendering a conducive environment for university students with physical disabilities: assessing availability of assistive facilities in Nigeria, Disability and Rehabilitation. *Disability and Rehabilitation Assistive Technology, 14* (4), 1-8.

Kamei-Hannan, C. (2008). Examining the accessibility of a computerized adapted test using assistive technology. *Journal of Visual Impairment & Blindness, 102*, 261–271.

Keinen, W. T. (2018). The lived experiences of students with severe mobility impairment at Addis Ababa University (AAU): A phenomenological perspective. *International Journal of Psychology and Counselling, 10* (1), 1-10.

Kharade, K., & Peese, H. (2012). Learning by E-Learning for Visually Impaired Students: opportunities or again marginalisation? *E–Learning and Digital Media, 9* (4), 439-448.

Koustriava, E. & Papadopoulos, K. (2014). Attitudes of individuals with visual impairments towards distance education. *Universal Access in the Information Society, 13*, 439-44.

Lang, H. G. (2002). Higher education for deaf students: research priorities in the new millennium. *Journal of Deaf Studies and Deaf Education, 7* (4), 267-280.

Lawal-Solarin, E. O. (2012). A survey of library and information services to physically-challenged students in academic libraries in Ogun State, Nigeria. *Library Philosophy and Practice*.

Lee, S. M., & Oh, Y. (2017). The Mediator role of perceived stress in the relationship between academic stress and depressive symptoms among e-learning students with visual impairments. *Journal of visual impairment & blindness, 111*(2), 123-134.

Lersilp, T., & Lersilp, S. (2017). A guideline of using assistive technologies and educational services for students with disabilities in higher education. *American Journal of Applied Sciences, 14* (5), 526-532.

Levy, L. G. G, & Ferreira, L. (2019). Hearing impairment and higher education: perceptions of students and employees in a Brazilian Public Institution. *Research, Society and Development, 9* (1), 1-15.

Madumere, C. P., Mbajiorgu, O., & Uwakwe, C. (2019). Information needs, library services and assistive technologies: Supportive measures to the visually impaired students in Nigeria university libraries. *Journal of Applied Information Science and Technology, 12* (1), 46-52.

Majinge, R. M., & Stilwell, C. (2013). Library services provision for people with visual impairments and in wheelchairs in academic libraries in Tanzania. *South African Journal of Libraries and Information Science, 79* (2), 38-50.

Menzi-Cetin, N., Alemdag, E., Tuzun, H., & Yıldız, M. (2017). Evaluation of a university website's usability for visually impaired students. *Universal Access in the Information Society, 16* (1), 151-160.

Moh, C. (2012). Student support services for post-secondary students with visual disabilities. *Educational Research and Reviews, 7* (22), 483-486.

Murray, M., Perez, J., Geist, D., & Hedrick, A. (2012). Student interaction with online course content: Build it and they might come. *Journal of Information Technology Education: Research, 11*, 125-140.

Mushome, A. M., & Monobe, R. J. (2013). The attitude of lecturers towards visually impaired students: A case study of one of the universities in the Limpopo province in South Africa. *US-China Education Review A, 3* (2), 108-113.

Napier, J., & Barker, R. (2004). Accessing university education: Perceptions, preferences, and expectations for interpreting by deaf students. *Journal of Deaf Studies and Deaf Education, 9* (2), 228-238.

Nhemachena, L., Kusangaya, S., & Gwitira, I. (2012). An evaluation of inclusive education of students with visual impairment in schools and university in Beira, Mozambique. *Journal of the American Academy of Special Education Professionals*, Fall, 76-98.

Niagara College Canada (n.d.). *Accessibility services*. Retrieved from https://www.niagaracollege.ca/accessibilityservices/disabilities-and-accommodations/mobility-impairments/

Nordin, N., Yunus, M. M., Zaharudin, R., Salehi, H., Yasin, M. H. M., & Embi, M. A. (2015). A review on higher education for hearing-impaired individuals. *Asian Social Science, 11* (24), 75-81.

Oh, Y., & Lee, S. M. (2016). The effects of online interactions on the relationship between learning-related anxiety and intention to persist among e-learning students with visual impairment. *International Review of Research in Open and Distributed Learning, 17* (60), 89-107.

Omede, A. A. (2015). The challenges of educating the visually impaired and quality assurance in tertiary institutions of learning in Nigeria. *International Journal of Educational Administration and Policy Studies, 7* (7), 129-133.

Ostrowski, C. P. (2016). Improving access to accommodations: Reducing political and institutional barriers for Canadian postsecondary students with visual impairments. *Journal of visual impairment & blindness, 110* (1), 15-25.

Otyola, W. R., Kibanja, G. M., & Mugagga A. M. (2017). Challenges faced by visually impaired students at Makerere and Kyambogo Universities. *Makerere Journal of Higher Education, 9* (1), 75-86.

Papadopoulos, K., & Koutsoklenis, A. (2009). Reading media used by higher-education students and graduates with visual impairments in Greece. *Journal of visual impairment & blindness, 103*, 772-779.

Papakonstantinou, D., & Papadopoulos, K. (2016). Social support provided to higher education students with visual Impairments by their sighted fellow students. *Turkish Online Journal of Educational Technology*, Special Issue December 2016, 1393-1400.

Pappas, M. A., Demertzi, E., Papagerasimou, Y., Koukianakis, L., Kouremenos, D., Loukidis, I., & Drigas, A. S. (2018). E-Learning for deaf adults from a user-centered perspective. *Education Sciences, 8* (206), 1-15.

Powell, D., Hyde, M., & Punch, R. (2013). Inclusion in postsecondary institutions with small numbers of deaf and hard-of-hearing students: Highlights and challenges. *Higher Education Research and Development, 28* (1), 85-98.

Quirke, M., McCarthy, P., & Mc Guckin, C. (2018). "I can see what you mean": Encouraging higher education educators to reflect upon their teaching and learning practice when engaging with blind/vision impaired learners. *All Ireland Journal of Teaching and Learning in Higher Education, 10* (1), 3371-33712.

Regec, V., & Regec, M. (2016). Accessibility of digital platforms at universities for students with visual Impairment and blindness. *E-pedagogium*, (IV), 53-68.

Ringlaben, R., Bray, M., Packard, A. (2013). Accessibility of American university special education departments' web sites. *Universal Access in the Information Society, 13* (2), 249–254.

Smith, D. H., & Andrews, J. F. (2015). Deaf and hard of hearing faculty in higher education: enhancing access, equity, policy, and practice. *Disability & Society, 30* (10), 1521–1536.

Tapu, R., Mocanu, B., & Zaharia, T. (2017). DEEP-HEAR: A Multimodal Subtitle Positioning System Dedicated to Deaf and Hearing-Impaired People. *IEEE Access*, XX.

Torres, F. C. (2019). Facing and overcoming academic challenges: Perspectives from deaf Latino/a first-generation college students. *American Annals of the Deaf, 164* (1), 10–36.

Tripathi, M. & Shukla, A., 2014. Use of assistive technologies in academic libraries: A Survey use of assistive technologies in academic libraries: A Survey. *Assistive technology: the official journal of RESNA, 26* (2), 105–118.

University of Leicester (n.d.). *Information for staff working with deaf or hearing impaired students.* Retrieved from: https://www2.le.ac.uk/offices/accessability/staff/supporting-students-with-disabilities/information-for-staff-working-with-deaf-or-hearing-impaired-students

World Wide Web Consortium (W3C) (2008), *Web content accessibility guidelines (WCAG) 2.0. W3C*. Retrieved from: https://www.w3.org/TR/WCAG20/

Zaid, Y. A., & Zaid, Y. (2017). The exclusion of persons with visual impairment in Nigerian academic libraries' websites. *Library Philosophy and Practice (e-journal).* 1601.

Zia, M.W. (2011). Digital library services for visually impaired students: A study of the University of Karachi. *Pakistan Journal of Library & Information Science, 12*, 1-6.

2.2. Study of the appropriate pedagogical approaches concerning accessible and inclusive DE programmes and the use of adapted material.

Objective

The identification of accessible and inclusive pedagogical approaches in higher education will form the basis for the design and development of educational material in a preliminary version.

Description

The literature was reviewed in a systematic way. Several databases were retrieved (e.g. Research gate, ERIC, Elsevier) as dominant resource. Also, university websites were sought as important sources of information on their adopted pedagogical approaches.

2.2.1. Study of the appropriate pedagogical approaches concerning accessible and inclusive DE programmes and the use of adapted material.

Accessible and inclusive education needs to be available to all university students (Anderson, 2018). However, some online learning practices do not meet the needs of students with disabilities (Burgstahler, 2015). In particular, uncaptioned videos are not accessible to students with hearing impairment, graphic image without alternative description is not accessible to screen readers used by students with visual impairment, content in a document or a web page without structured heading can be tiresome for students with visual impairment, web pages that demand the use of a mouse are not accessible to students with mobility impairment (Burgstahler, 2015).

Universal design (UD) has emerged as a context for defining an inclusive model for covering all aspects of instruction. Pedagogical (and technical) issues need to be addressed so as the courses to be accessible to all students (Burgstahler, 2015). A universal design course would respond to the preferred access methods (e.g. alternative keyboard, speech input) and output preferences (e.g. video, audio text) of students (Burgstahler, 2015). Implementing UD reduces the necessity for accommodations for students with disabilities (Burgstahler, 2015). For instance, captioning online courses means that students with hearing impairment do not need an accommodation to access the content (Burgstahler, 2015). Captions could benefit not only students with hearing impairment but other students as well (Burgstahler, 2015).

The design of both accessible and inclusive online curriculum can be approached via the principles of Universal Design (Kerr & Baker, 2013). Access to knowledge for all students depends on how the curriculum is developed, delivered and assessed (Kerr & Baker, 2013). Six principles give emphasis on the significance of inclusive curriculum design for all students studying in distance education (Kerr & Baker, 2013).

According to Kerr and Baker (2013), those principles and their explanation are the following:

- **Principle 1** - All inherent requirements for the course need to be clearly articulated and available to students prior to enrolment: The full participation of students with disabilities may be prevented if they are ignorant of inherent requirements (namely, the aspects of the curriculum that need to be fulfilled in order the course to be finished) of a course and this may be proved problematic. For this reason, it is of utmost importance the information concerning significant inherent requirements to be offered in all

documentation about the courses. Making inherent requirements clearly is advantageous to all students, for two main reasons. Firstly, students studying in distance education do not have immediate contact with support services and so are less possible to access them than on-campus education. Secondly, for those students, the knowledge of the inherent requirements of a course is possible to make a big difference in course selection. Both two reasons are even more relevant for students with disabilities studying in distance education.

- **Principle 2** - Regularly evaluate the accessibility and inclusiveness of courses and modify accordingly: It is important the feedback and amendment of the course, given that the courses offered in distance education can be slower to change than courses delivered in an on-campus education. It is even better when this feedback is given early in the course life cycle. It is important to ask students if they have access to all of the learning materials and technologies, if they comprehend the course requirements and if they know who to contact if they want help.

- **Principle 3** - All learning materials and learning technologies used in the course enrolment, delivery, and assessment to be accessible by students using assistive technologies: It is suggested that before the institutional investment in any technology connected to enrolment, teaching or assessment of students, an accessibility statement should be secured from the developer and that the pertinent system should be checked by students with disabilities to underline possible challenges. In terms of the supply of course materials to students studying in distance education, the learning management system and all materials placed in it should be accessible to assistive technologies. Lecture notes should be available in Word or accessible PDF and also audio materials should be available through transcriptions, ensuring access to all students with disabilities.

- **Principle 4** - All learning materials to be clearly presented in plain English to facilitate optimum communication: The excessive use of colloquialisms and acronyms can be difficult for many students. Even if acronyms and other terms are initially described in lecture notes, it is not easy for a student who is using assistive technologies to go back in a document to reconsider what the acronym represents. It is suggested that a glossary of terms be developed, where a considerable number of acronyms are used. This is a helpful strategy not only for students with disabilities but for all enrolled in the course.

- **Principle 5** - Teaching staff to adopt a flexible and inclusive attitude with regard to making alternative arrangements as required due to disability: This principle should be a core element for professional development for all teaching and support staff engaged in the writing, delivery and assessment of curriculum.

- **Principle 6** - Flexible time lines, assessment tasks, and course requirements: Flexibility in timelines, tasks, assessments and course requirements is even more significant in distance education than in an on-campus education.

In terms of the above-mentioned principles, the first two are referred to the area of curriculum development in which the course's demands need to be explicitly articulated and available to students before their enrolment and educators need to periodically evaluate the inclusiveness and accessibility of their courses and change accordingly (Kerr & Baker, 2013). The other three principles (namely the third, the fourth, and the fifth) are referred to the area of curriculum delivery in which all learning materials and learning technologies should be accessible, presented in plain language and inclusive attitude (Kerr & Baker, 2013). The last principle is referred to the area of student assessment (Kerr & Baker, 2013).

For many years accessibility in distance education (e-learning) has been addressed from the technical side, but in the last few years a new point of view considers the learning process in all its aspects (Guglielman, 2010). For the implementation of accessible distance education and specifically the creation of accessible online course content, a learner-centered approach to teaching and learning should be adopted). This urges us to consider the unique learning styles and needs of the students (Coombs, 2010). Accessible online course content should be modularized and organized (e.g. dividing lessons into small pieces/parts as it has been supported that it is an essential learning tool for students with disabilities), should provide a text equivalent for every non-text element (e.g. text description to the image), include captions for multimedia presentations by helping, for example, students with hearing impairment to understand the audio-only content, use color carefully, use headers to make data tables accessible (Coombs, 2010). In this perspective, accessible distance education programmes (e-learning courses) should be the results of a participatory design, involving domain experts, technologists, pedagogists, support workers, disability experts and end-users, and should be designed for all users, taking into consideration the principles of Universal Design (Guglielman, 2010).

According to Guglielman (2010), the whole process of accessible distance education can be treated with three main steps:

- Predesign - It is referred to learning theories and paradigms, providing a theoretical construct to the pedagogical model and to the design of the learning environment.
- Pedagogical design.
- Technological design - It is the phase in which the environment of distance education is designed by describing the communication architecture and implementing the accessibility technical standards.

Other studies related to this topic suggest general frameworks and models without explaining how learning activities should be designed and planned (Guglielman, 2010). Studies about the design of accessible distance education considering both technological and pedagogical dimensions have not yet been reported at a national level (Guglielman, 2010). Distance education courses are not tailored to the needs of students with disabilities and there is a lack of awareness about learner-centered approaches, such as participatory design and Universal Design (Guglielman, 2010).

Universal Design for Learning (UDL) adapts UD principles for purposes of curriculum and instruction (Rao & Tanners, 2011). UDL implements the concepts of inclusion and accessibility beyond physical environments, designs teaching and learning opportunities considering all students, including those with disabilities (Dalton, Lyner-Cleophas, Ferguson & McKenzie, 2019). The UDL aims at the creation of an accessible and inclusive learning experience to the greatest number of students and is achieved via flexible curricular material and activities (Durham College, n.d.). Introducing UDL principles into an online course, opportunities and challenges have emerged for pedagogical practice (Anderson, 2018). UDL is associated not only with (assistive) technology but also with pedagogy or instructional practices used for students with and without disabilities (King-Sears, 2009).

Effective pedagogy involves appropriate curriculum planning and design and effective instructional strategies which slightly differ from on-campus education (Oyeleke, Olugbenga, Oluwayemi & Sunday, 2015). Distance education is not only about technology, but also a complete change of teaching and learning process using technologies and applying relevant learning theories due to the diversity of online students (Oyeleke et al, 2015). However, learning theories do not give in-depth knowledge into exactly what teachers can do to make distance learning more accessible and thus, further exploration of this aspect is needed considering learning design tools and their potential to assist teachers to develop accessible distance education (Seale & Cooper, 2010). The concept of

learning design in the context of distance education is strongly connected to lesson planning or course design (Seale & Cooper, 2010).

Inclusive design for online courses links the Web Content Accessibility Guidelines (WCAG) and the UDL framework in order to respond to the variability of students (Gronseth, 2018). The UDL context can be implemented to the learning objectives, methods, materials and assessments of a course (Gronseth, 2018).

According to Gronseth (2018) the WCAG areas (perceivable, operable, understandable, and robust) can be connected to UDL with the following guidelines:

- Perceivable - The interfaces of course websites and the course materials should be perceivable to learners. The provision of alternative format links to the UDL principle of providing various means of representation that suit the needs of students. The information can be available through text-to-speech, braille, large print, etc. The perceivable aspect is improved when user adaptation options are offered and this agrees with the UDL representation guideline of giving options for perception through customization and alternative information. Perception is also enhanced when the features of content are distinguishable which can be accomplished by incorporating greater contrast, allowing turning sound on/off, ensuring that text is not presented as image only.
- Operable - Students access course materials and activities in various ways (e.g. using assistive technology like screen readers and switch controls). The operable area is connected to the UDL principle of providing various means of action and expression and improves access for students using assistive technologies. Operability is improved via keyboard navigation functionality, adjustable timing, consistent and clear organization of course sites and materials.
- Understandable - Instructional designers and educators could take into consideration the reading levels and background knowledge of students in order to understand jargon and abbreviations in written instructions.
- Robust - In this context, the word robust is referred to the designed materials and technologies for diverse users. Robust course materials, websites are compatible with assistive technologies, making easier options for access and perception which concerns the UDL action and perception guideline of giving options for physical action. A practical way to check compatibility is by listening to the course materials utilizing a screen reader.

Consequently, the inclusive design for online courses could include WCAG and UDL framework to support different learner abilities, needs, and preferences In particular, practical applications of these guidelines involve strategies as regards the UDL framework areas of engagement, representation of content and learner action and expression (Gronseth, 2018).

Throughout the world, more and more students are registering in distance education programs and therefore it is significant now to design curriculum that considers educational principles and shows elements of engagement and pedagogy (Chugh, Ledger & Shields, 2017). Effective curriculum design is important for any educational system, securing that the learning journey of students is successful. A contemporary curriculum design for distance education can be formed including pedagogy, technology and an engaged community of learners (Chugh et al., 2017).

2.2.2. References

Anderson, R. (2018). Universal Design Learning (UDL) in Higher Education. Retrieved from: https://www.researchgate.net/publication/326274393_Universal_Design_Learning_UDL_in_Higher_Education

Burgstahler, S. (2015). Opening doors or slamming them shut? Online learning practices and students with disabilities. Social Inclusion, 3 (6), 69-79.

Chugh, R., Ledger, S., & Shields, R. (2017). Curriculum design for distance education in the tertiary sector. Turkish Online Journal of Distance Education-TOJDE, 18 (1).

Coombs, N. (2010). Online learning and students with disabilities. In N. Coombs (Ed.), Making online teaching accessible: inclusive course design for students with disabilities (1st edition, pp.24-27). San Francisco: Jossey Bass.

Dalton, E. M., Lyner-Cleophas, M., Ferguson, B. T., & McKenzie, J. (2019). Inclusion, universal design and universal design for learning in higher education: South Africa and the United States. African Journal of Disability, 8 (0), 1-7.

Durham College. (n.d.). UDL home page. Retrieved from: https://durhamcollege.ca/cafe/teaching/udl/

Gronseth, S. (2018). Inclusive design for online and blended courses: Connecting web content accessibility guidelines and universal design for learning. Educational Renaissance, 7, 14-22.

Guglielman, E. (2010). E-learning and disability: Accessibility as a contribute to inclusion. In K. Maillet, R. Klamma, T. Klobucar, D. Gillet, & M. Joubert (Eds.), Proceedings of the 5th doctoral consortium at the european conference on technology enhanced learning, Barcelona, Spain, September 29. Retrieved from http://ceur-ws.org/Vol-709/paper06.pdf

Kerr, S., & Baker, M. (2013). Six practical principles for inclusive curriculum design. In Tynan, B., Williams, J., & James, R. (Eds.), Outlooks and opportunities in blended and distance learning (pp. 76-82). USA: Information Science Reference (an imprint of IGI Global).

King-Sears, M. (2009). Universal design for learning: Technology and pedagogy. Learning Disability Quarterly 35 (2), 8-17.

Oyeleke, O., Olugbenga, F. A., Oluwayemi, O. E., & Sunday, A. J. (2015). Changing the landscape of learning: Critical factors in open and distance learning. Journal of Education and Practice, 6 (13), 53-62.

Rao, K., & Tanners, A. (2011). Curb cuts in cyberspace: Universal instructional design for online courses. Journal of Postsecondary Education and Disability, 24 (3), 211 – 229.

Seale, J., & Cooper, M. (2010). E-learning and accessibility: An exploration of the potential role of generic pedagogical tools. Computers & Education, 54, 1107–1116.

2.3. Suggested Software to access adapted educational material

Distance Education (DE) programs utilize mostly educational material in electronic form. Electronic educational material could be provided in many different formats. Individuals with visual, hearing and mobility impairments have specific needs in order to access educational material provided in electronic form.

Objective

The present section presents the suggested software to be used by individuals with visual impairments in particular, in order for them to access electronic educational material provided in different file formats.

Description

The most essential computer software for individuals with visual impairments is the Screen Reader. However not all software applications are developed in such a way that they would work with screen readers. Hence not all software applications are accessible by screen readers and therefore cannot be used by individuals with visual impairments.

Below are listed the suggested screen reader and software applications (that do work with suggested screen reader) in order an individual with visual impairments to read electronic educational material provided in different file formats (e.g. accessible text books, spread sheets, presentations, e-books, programming language file types, compressed files, etc.).

In order to test the accessibility of available software, an extensive list of sample files of different file formats was created (e.g. Text files, spread sheet files, presentation files, e-books, files, compressed files, programming language source code files etc.) and accessed with the suggested screen reader.

All suggested software is open source, freely available to download and use, have a user interface (menu) available in English, French languages and most of them also in Arabic language.

2.3.1. Screen Reader

The screen reading software is probably the most essential software for all individuals with visual impairments. It allows the user to listen to what is displayed, as text (usually), on the computer screen with a speech synthesizer. It also allows the user to interact with the computer, navigate through the computer's operating system, third party applications and files.

However not all software applications are accessible by screen readers.

There are several screen readers available. The suggested screen reader software is **NVDA** (NonVisual Desktop Access)

Developed by: NV Access

URL: https://www.nvaccess.org/

Version tested: 2019.3.1

License: GNU General Public License (Version2)

NVDA is the most prevalent, free to use screen reader software that provides many useful functionalities to the blind users especially in the context of the INSIDE project considering its particularities.

NVDS is 100% free to use globally, open source, with menu localization and built in multi-lingual speech synthesizer available in Greek, English, French and Arabic languages among others, Braille support to output information on a variety of supported refreshable Braille displays, and allows the creation of a portable instance of NVDA on a portable USB drive or another writable media in order to easily use NVDA on different computers, on the go.

However NVDA is only available for PCs running Microsoft Windows Operating System (OS) and is not compatible with Linux or Mac OS.

Mac OS has **VoiceOver** (https://www.apple.com/accessibility/iphone/vision/) as a built-in screen reader while the most popular Linux based screen reader is **ORCA** (https://help.gnome.org/users/orca/stable/).

On the other hand NVDA is a very flexible and extensible screen reader. Among other features NVDA provides some useful functionality through Add-ons provided by the community. NVDA add-ons are additional packages that can be downloaded and installed into your copy of NVDA to enhance existing functionality or add additional features.

A list of NVDA Community Add-ons can be found at: https://addons.nvda-project.org/index.en.html

Some of the most useful ones are listed bellow:

Focus Highlight Add-on

By drawing a coloured rectangle, this NVDA Add-on enables partially sighted users, sighted educators, or developers to track the location of the NVDA navigator object and the focused object/control. This is very useful for developers who do not need to listen to the speech synthesizer when working on an application or creating contend while using the screen reader.

Authors: Takuya Nishimoto, Karl-Otto Rosenqvist

Download stable version: https://addons.nvda-project.org/addons/focusHighlight.en.html

Notepad ++ Add-on

This NVDA Add-on improves the accessibility of the Notepad++ text editor.

Authors: Derek Riemer, Tuukka Ojala

Download Stable Version: https://addons.nvda-project.org/addons/notepadPlusPlus.en.html

Calibre Add-on

This NVDA add-on provides some accessibility enhancements for the interface of the Calibre e-Book Management.

Author: Javi Dominguez

Download stable version: https://addons.nvda-project.org/addons/calibre.en.html

Access8Math Add-on

This NVDA add-on provides the function of reading math content. Although the original NVDA is already equipped with this feature by applying MathPlayer, some functions still needed to be improved. This add-on allows NVDA to better read math content written in MathML in web browsers and math content in MS Word text editor when written in MathType.

Author: Woody Tseng

Download stable version: https://addons.nvda-project.org/addons/access8math.en.html

VLC Media Player Add-on

This NVDA Add-on provides some accessibility features for the VLC Media Player.

Author: Javi Dominguez

Download stable version: https://addons.nvda-project.org/addons/vlc.en.html

2.3.2. Productivity suite

A productivity suite is essential software for a student. A productivity suite is a software bundle of productivity applications. The bundled set of applications typically includes at least: a text editor, a spreadsheet editor and a presentation program. However it may include other useful applications like database management system, diagramming/chart software etc.

There are several productivity suites available in order to produce and edit text documents, presentation documents and spread sheet documents.

The suggested productivity suite is **LibreOffice**.

Developed by: The Document Foundation

URL: https://www.libreoffice.org/

Version tested: 6.3.5.2 (x64)

License: Mozilla Public License Version 2.0

LibreOffice is the most popular, free to use productivity suite that provides a text editor, a spreadsheet editor and a presentation program as well as many other useful applications, and works great with NVDA screen reader.

LibreOffice is free to use, open source, cross platform productivity suite, with menu localization and built in multi-lingual dictionary available in Greek, English, French and Arabic languages among others, and allows the creation of a portable instance of LibreOffice on a portable USB drive or another writable media in order to easily use LibreOffice on different computers, on the go.

Microsoft Office (MS Office) (www.microsoft.com) is probably the most popular productivity suite and also works great with NVDA screen reader.

However MS Office is proprietary software (not free).

2.3.3. MathPlayer

Math Player is a universal math reader that enables math written in MathML, to be spoken in assistive technology products. MathPlayer can make documents more accessible by providing a means for screen readers and screen magnifiers to speak, navigate, and convert to braille math in those documents.

MathPlayer can work with NVDA screen reader to provide access to the math included in web browsers and documents such as Microsoft Word and PowerPoint for Windows (provided that **MathType** is used in MS Word and MS PowerPoint).

Developed by: Design Science, Inc.

URL: https://www.dessci.com/en/products/mathplayer/

Version tested: MathPlayer 4

License: Product owned by Design Science, Inc., protected by copyright law.

However **MathType is required** for this capability in MS Word and MS PowerPoint.

MathType

Math created with the EquationEditor which is included in MS Word doesn't work with screen readers. MathType is a powerful equation editor for Windows and Macintosh that allows the creation of mathematical notation for word processing, web pages, desktop publishing, presentations, elearning, and for TeX, LaTeX, and MathML documents.

However MathType is proprietary software (not free).

Developed by: Design Science, Inc.

URL: https://www.dessci.com/en/products/mathtype/

Version tested: MathType 6.9

License: Product owned by Design Science, Inc., protected by copyright law.

2.3.4. MathCast

Math created with the EquationEditor which is included in MS Word doesn't work with screen readers

The suggested math equation editor software is MathCast.

MathCast is a mathematical equation editor, an application that allows the user to input mathematical equations in documents, emails, and web pages.

Developed by: Tom Chakam & Timothy Lee

URL: http://mathcast.sourceforge.net/home.html

Version tested: 0.92

License: GNU General Public License version 3.0

MathCast is a free and open source, cross platform mathematical equation editor application and works great with NVDA screen reader.

However, it has menu localization available only in English language.

MathCast allows equations to be inserted into written documents of any type: equation sheets, lab reports, study guides, and so on. MathCast's equations can be easily copied and pasted into email, webmail, and other applications. The equations can be rendered graphically to the screen, to picture files, or to MathML. MathCast supports output to picture files, including: BMP, PNG, and EMF, while equations can be exported to MathML. Thus allowing equations to be incorporated in presentations and web pages. MathCast is also an *Equation List Manager*, and is capable of organizing a number of equations in a single list. This enables users to to manage, modify, view, edit, and reedit all the mathematics of a project (i.e. document, webpage, etc.) all at the same session.

2.3.5. Text Editor - Source Code /Development

Any text editor, apart from the simple task of writing plain text, can be used for computer programming and source code development and vice versa.

A source-code/development editor is a text editor program designed to have additional specific functionalities for editing source code of computer programs. However it can also be used as a simple text editor to write plain text and for note taking tasks.

There are several source code editors available.

The suggested source code editor software is **Notepad++**

Developed by: Don Ho

URL: https://notepad-plus-plus.org/

Version tested: 7.8.2 (x64)

License: GNU General Public License

Notepad++ is a free to use, open source, cross platform source code/development text editor with menu localization available in Greek, English, French and Arabic languages among others, and allows the creation of a portable instance of Notepad++ on a portable USB drive or another writable media in order to easily use it on different computers, on the go.

Notepad++ supports the following programming languages:

ActionScript	Ada	ASN.1	ASP	Assembly
AutoIt	AviSynth scripts	BaanC	batch files	Blitz Basic
C	C#	C++	Caml	CMake
Cobol	CoffeeScript	Csound	CSS	D
Diff	Erlang	escript	Forth	Fortran
FreeBASIC	Gui4Cli	Haskell	HTML	INI files
Intel HEX	Inno Setup scripts	Java	JavaScript	JSON
JSP	KiXtart	LaTeX	LISP	Lua

Makefile	Matlab	MMIX	Nimrod	nnCron
NSIS scripts	Objective-C	OScript	Pascal	Perl
PHP	PostScript	PowerShell	PureBasic	Python
R	Rebol	Registry script (.reg)	Resource file	Ruby
Rust	Scheme	Shell script	Smalltalk	SPICE
SQL	Swift	S-Record	Tcl	Tektronix HEX
TeX	txt2tags	Visual Basic	Visual Prolog	VHDL
Verilog	XML	YAML		

Table 1 Notepad++ supported programming languages

Notepad++ supports the above listed programming languages for their syntax highlighting (customizable), syntax folding, auto-completion (customizable), function list (customizable via PCRE in xml file).

In order to use Notepad++software with NVDA screen reader, the **Notepad add-on** should be added to the installed NVDA instance.

2.3.6. e-Book manager

An electronic book (e-Book) is a book in digital form and is actually an electronic version of a printed book, consisting all elements available by a printed book. E-Books are readable on computers, tablet devices or dedicated e-reader devices.

EPUB (.ePUB file) is one of the most widely known and used formats for e-books. It was developed to provide a reflowable, platform-independent electronic book.

An e-Book management software can be used for managing e-books on a PC.

The suggested e-Book manager software is **Calibre.**

Developed by: Kovid Goyal

URL: https://calibre-ebook.com/

Version tested: 4.6.0 (x64)

License: GNU General Public License v3

Calibre is a free to use, open source, cross platform e-Book manager software with menu localization available in Greek, English, French and Arabic languages among others, and allows organizing existing e-books into virtual libraries, displaying, editing, creating and converting e-books, as well as syncing e-books with a variety of e-readers. Editing books is supported for EPUB and AZW3 formats. Moreover calibre can extract e-books to .docx, .pdf, .txt, .htmlz file formats. It allows the creation of a portable instance of Calibre on a portable USB drive or another writable media in order to easily use it on different computers, on the go

In order to enhance accessibility for the interface of Calibre eBook Management while using it with NVDA screen reader, the **Calibre add-on** should be added to the installed NVDA instance.

2.3.7. File archiver

In many cases educational material must be organized in archives. In such cases a file archiver is the appropriate software to use. A file archiver is a computer program that combines a number of files together into one archive file, or a series of archive files, for easier transportation or storage.

The suggested file archiver software is **7-Zip.**

Developed by: Igor Pavlov

URL: https://www.7-zip.org/

Version tested: 19.00 (x64)

License: GNU LGPL license, BSD 3-clause license and unRAR license.

7-Zip is free to use, open source, cross platform file archiver with menu localization available in Greek, English, French and Arabic languages among others, and allows the creation of a portable instance of 7-Zip on a portable USB drive or another writable media in order to easily use 7-Zip on different computers, on the go.

7-Zip supports the following formats:

- Packing / unpacking: 7z, XZ, BZIP2, GZIP, TAR, ZIP and WIM
- Unpacking only: AR, ARJ, CAB, CHM, CPIO, CramFS, DMG, EXT, FAT, GPT, HFS, IHEX, ISO, LZH, LZMA, MBR, MSI, NSIS, NTFS, QCOW2, RAR, RPM, SquashFS, UDF, UEFI, VDI, VHD, VMDK, WIM, XAR and Z.

2.3.8. Video Player

Educational material could include videos, DVDs, Audio CDs, podcasts and various streaming protocols. In such cases a multimedia player is necessary to access these media.

The suggested multimedia player and framework that plays most multimedia files as well as DVDs, Audio CDs, VCDs, and various streaming protocols is **VLC media player.**

Developed by: VLC team of developers

URL: https://www.videolan.org/

Version tested: 3.0.8 (x64)

License: GNU General Public License Version 2

VLC is a free to use, open source, cross-platform multimedia player and framework that plays most multimedia files as well as DVDs, Audio CDs, VCDs, and various streaming protocols. It provides the option for menu localization available in Greek, English, French and Arabic languages among others, and allows the creation of a portable instance of VLC on a portable USB drive or another writable media in order to easily use it on different computers, on the go.

VLC supports among others the following video, audio, subtitle codecs/file formats:

MPEG-1/2, DivX® (1/2/3/4/5/6), MPEG-4 ASP, XviD, 3ivX D4, H.261, H.263 / H.263i, H.264 / MPEG-4 AVC, Cinepak, Theora, Dirac / VC-2, MJPEG (A/B), WMV 1/2, WMV 3 / WMV-9 / VC-1, Sorenson 1/3, DV, On2 VP3/VP5/VP6, Indeo Video v3 (IV32), Real Video (1/2/3/4).

MPEG Layer 1/2, MP3 - MPEG Layer 3, AAC - MPEG-4 part3, Vorbis, AC3 - A/52, E-AC-3, MLP / TrueHD>3, DTS, WMA 1/2, WMA 3, FLAC, ALAC, Speex, Musepack / MPC, ATRAC 3, Wavpack,

Mod, TrueAudio, APE, Real Audio, Alaw/µlaw, AMR (3GPP), MIDI, LPCM, ADPCM, QCELP, DV Audio, QDM2/QDMC, MACE.

DVD, Text files (MicroDVD, SubRIP, SubViewer, SSA1-5, SAMI, VPlayer), Closed captions, Vobsub, Universal Subtitle Format (USF), SVCD / CVD, DVB, OGM, CMML, Kate.

ID3 tags, APEv2, Vorbis comment.

In order to use VLC software with NVDA screen reader, the **VLC Media Player add-on** should be added to the installed NVDA instance.

2.3.9. R data

The RData format (.rdata or . rda files) is a format designed for use with R, a programming language and environment for statistical computing and graphics.

There are many statistical software options available.

The suggested statistical software is **R**.

R is an integrated suite of software facilities for data manipulation, calculation and graphical display.

Developed by:

URL: https://www.r-project.org/

Version tested: 3.6.2

License: GNU General Public License

R is a free, cross platform software environment for statistical computing and graphics.

As statistical software it could be used by blind users who rely on screen reader software to have access to printed text. It can be installed and used without any modification. Using the terminal window instead of the GUI-based R console is a way to improve the experience of the blind user. The use of commands as the standard way of operating means that the blind user works the same way as any sighted user.

2.4. Development of the educational material and the alternatives in a preliminary version.

Objective

The creation of educational material in order individuals with ViHeMo impairments to assess its accessibility.

Description

The educational material and the file formats were selected in order to meet the needs of individuals with ViHeMo impairments.

2.4.1. Accessible Books

Objective

The availability and accessibility of digital or/and printed books with simple content for individuals with print disabilities and the conversion of books to different file formats.

MS Word (Greek Accessible Book)

Objective

The creation of a Greek accessible digital book in MS Word document file format (.docx) for individuals with visual or mobility/physical impairment.

Description

The book selection criteria were as follows: a) to be course book, b) to be a Greek digital book, c) to be about 200 pages and d) to be simple in its structure (e.g. mainly text, without many graphics, tables). After searching for digital books, the Greek book "Education and Disability" was selected. The book was found on PDF file on the website https://www.openbook.gr/ekpaideysi-kai-anapiria/.

The file name is "***Greek Accessible Book.docx***"

Development Procedure

The content of the book was copied to a word file. The Microsoft Word file was selected as it is a commonly used application among individuals with impairments and the text within Word documents can be easily read by screen readers. In order for Word document to be fully accessible, core accessibility principles (e.g. Microsoft accessibility

https://support.microsoft.com/en-us/office/make-your-word-documents-accessible-to-people-with-disabilities-d9bf3683-87ac-47ea-b91a-78dcacb3c66d?redir=0&correlationid=f8839df1-e881-45a4-9f17-1938a0ab30f5&ui=en-us&rs=en-us&ad=us&ocmsassetid=ha101999993#bkmk_winaltvisuals2019)

were followed. For instance, use of headings, meaningful hyperlinks, alternate text for image, lists, document language identification, page numbering, table of contents.

MS Word (English Accessible Book)

Objective

The creation of an English accessible printed book in MS Word document file format (.docx) for individuals with visual or mobility/physical impairment.

Description

The book selection criteria were as follows: a) to be course book, b) to be an English printed book, c) to be about 200 pages and d) to be simple in its structure (e.g. without many images, tables). After

searching for printed books, the English book "Assistive technology in Special Education" was selected.

The file name is "*English Accessible Book.docx*".

Development Procedure

The content of the book was scanned by using the professional book scanning, the ATIZ Bookdrive Pro. The ATIZ BookDrive Pro converted the book to digital format. Editing was made efficient with BookDrive Editor Pro. The digital format (jpg) was converted to word file by using the software Dolphin EasyConverter – OCR Editor. In order for Word document to be fully accessible, core accessibility principles were followed. For instance, use of headings, lists, meaningful hyperlinks, alternate text for image, document language identification, page numbering, table of contents, footnotes.

2.4.2. DAISY format

Objective

The creation of DAISY format (as it is specifically designed) for use by individuals with print disabilities, including visual impairment, mobility/physical impairment.

Description

The files "*Greek Accessible Book.docx*" and the "*English Accessible Book.docx*" converted to DAISY.

The file names in DAISY format are "*Greek Accessible Book DAISY.zip*" and "*English Accessible Book DAISY.zip*".

Development Procedure

Although the free MS Word add-in "*Save As DAISY*" was created to produce DAISY file format, it is no longer supported. According to the DAISY Consortium, "*Save as DAISY is no longer being developed or supported. The most recent version of Save As DAISY was released in December 2011. This page is presented for people running older applications and as a record of activity. These tools do not work on versions of MS Office newer than 2013 including Office 16 and Office 365, or on Windows 10*" (https://daisy.org/info-help/document-archive/archived-projects/save-as-daisy-ms-word-add-in/). In that case, an alternative is the software Dolphin EasyConverter which is compatible with Windows 7, 8 and 10. Everyone can use the software Dolphin EasyConverter for free for 30 days and it is totally free of cost for developing countries. This software was used for converting the files to DAISY format. On the software the output type is DTB. After choosing the output type, different options are given. Specifically, the type of DTB (Daisy 2.02 and Daisy 3) and audio settings. When the conversion is completed, the option "view output" is selected. Then, by default, the Dolphin EasyReader opens and the file is accessible for reading. There is free EasyReader App for iOS and Android.

2.4.3. EPUB

Objective

The creation of EPUB file format as it is the current industry standard in digital publishing.

Description

The files "Greek Accessible Book.docx." and the "English Accessible Book.docx." converted to EPUB file format.

The file names in EPUB are: "**_Greek Accessible Book ePUB.zip_**" and the "**_English Accessible Book ePUB.zip_**".

Development Procedure

The conversion was done by using Word to EPUB by DAISY (https://daisy.org/activities/software/wordtoepub/). After starting the setup program, a button is installed on the ribbon as a Word Add-in. The EPUB files created by this tool can be used by many EPUB reader apps. Thorium Reader was installed on the computer. Thorium Reader is a free and open source EPUB reader for Windows 10, MacOS and Linux (https://daisy.org/info-help/guidance-training/reading-systems/thorium-epub-reader-quick-start-guide/).

2.4.4. Accessible Sample Book

Objective

The availability and accessibility of image content, including diagrams, charts, graphs, photographs and more for individuals with print disabilities and the conversion of this document to different file formats.

Description

The book selection criteria were as follows: a) to be course book, b) to be available on both Greek and English language, b) to contain complex content (images, tables, frames etc.). After searching for books, the following two course books were selected: "Development through the lifespan" of Berk, L. E. (2018 in English language and 2019 in Greek language) and "Educational Technology for teaching and learning" of Newby, Stepich, Lehman & Russell (2006).

Development Procedure

The "_Greek Accessible Sample Book_" created in MS Word (file name: "**_Greek Accessible Sample Book.docx_**") and it was converted to DAISY format (file name: "**_Greek accessible sample book DAISY.zip_**") and EPUB (file name: "**_Greek Accessible Sample Book ePUB.zip_**") following the same development procedure, as previously. The "Greek Accessible Sample Book" is also written in English language and so the following documents were created as well: "**_English Accessible Sample Book.docx_**", "_English accessible sample book DAISY.zip_" and "**_English Accessible Sample Book ePUB.zip_**".

2.4.5. Presentations on PowerPoint

Objective

The availability and accessibility of PowerPoint presentations (which are commonly used in lectures) for use by individuals with ViHeMo impairment.

Description

The PowerPoint presentations contain two different sections from the book "*Development through the lifespan*" of Berk, L. E. (2018 & 2019). The two sections contain text, photograph, diagram, graph, table with data.

The file names are "*Greek Accessible Presentation.pptx*" and "*English Accessible Presentation.pptx*".

Development Procedure

After selecting the content of slides, accessibility principles were followed (e.g. Microsoft accessibility for PowerpPoint https://support.microsoft.com/en-us/office/make-your-powerpoint-presentations-accessible-to-people-with-disabilities-6f7772b2-2f33-4bd2-8ca7-dae3b2b3ef25). For example, use of title (it is presented as a heading to screen reader users), slide reading order, alternative text and verbal description for images, headers in the table, links. Two files were created, one in Greek and the other in English.

2.4.6. Verbal descriptions of images

Objective

The accessibility of visual images through verbal descriptions by enabling individuals with visual impairment to form a mental image of what they cannot see.

Description

The following six images were selected. The image criteria were to represent different academic disciplines such as arts, history, physics, medicine.

The file names are "*Greek Verbal Descriptions of images.docx*" and "*English Verbal Descriptions of images.docx*". The first file has been translated into English.

Development Procedure

Each image is described based on depicted content, without conveying additional information derived from the surrounding text or the acquired knowledge of the person who describe it.

Figure 1 The Discobolus of Myron
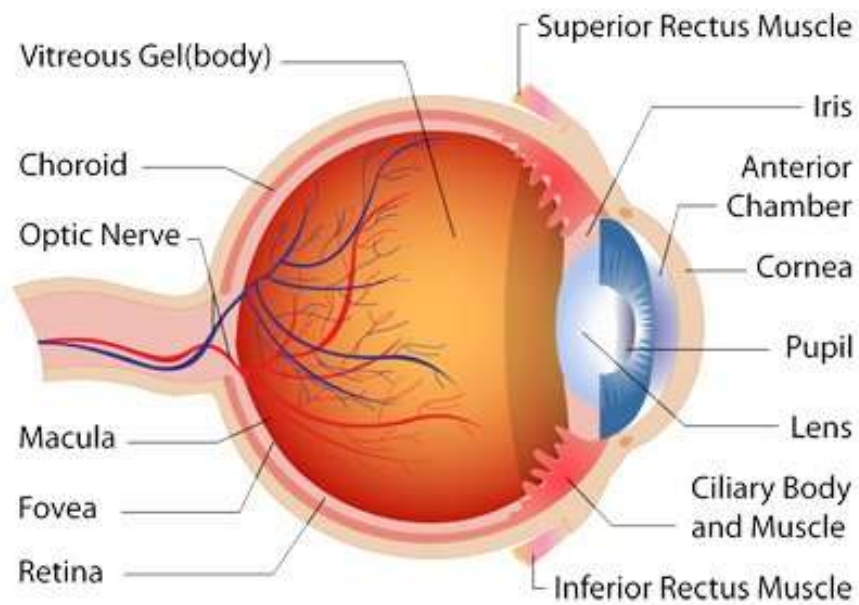
Figure 2 Eye Anatomy
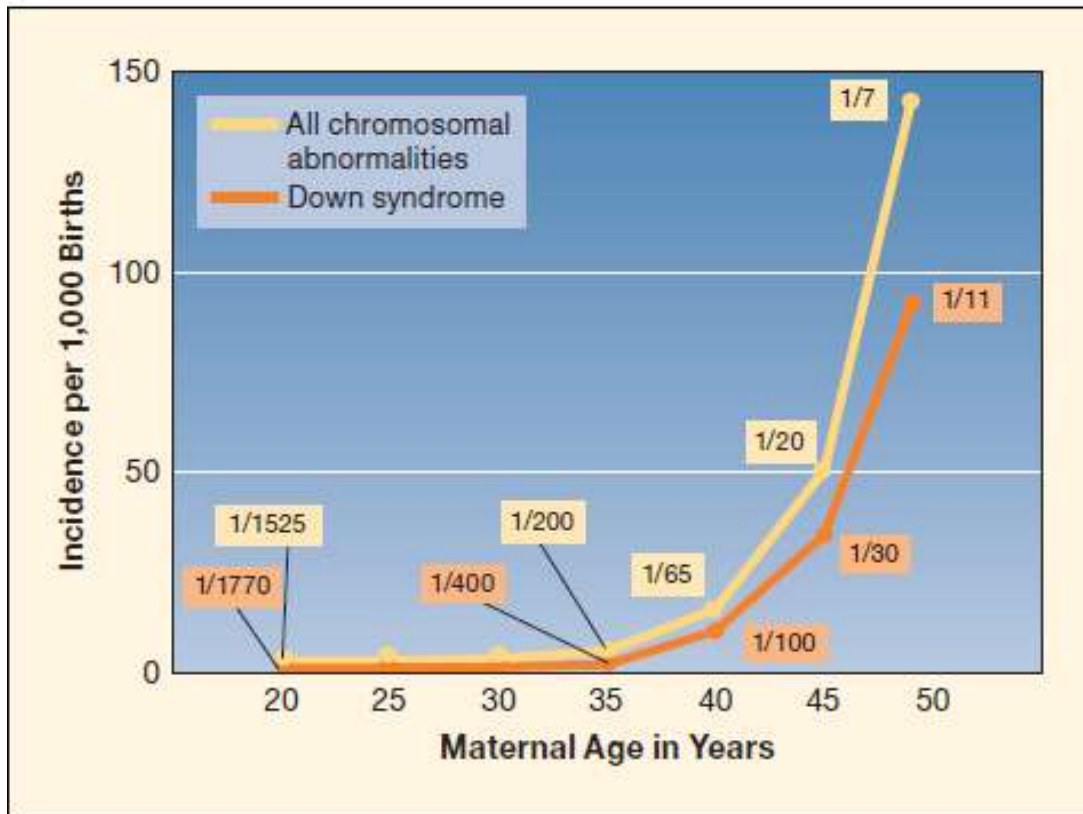
Figure 3 Risk of Down Syndrome and all chromosomal abnormalities by maternal age
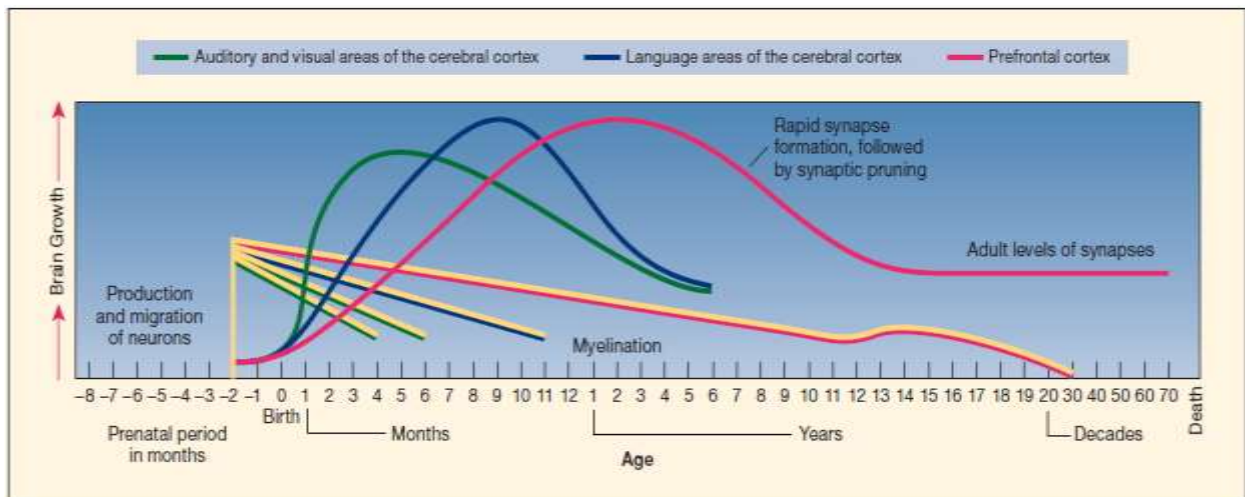
Figure 4 Major Milestones of Brain Development
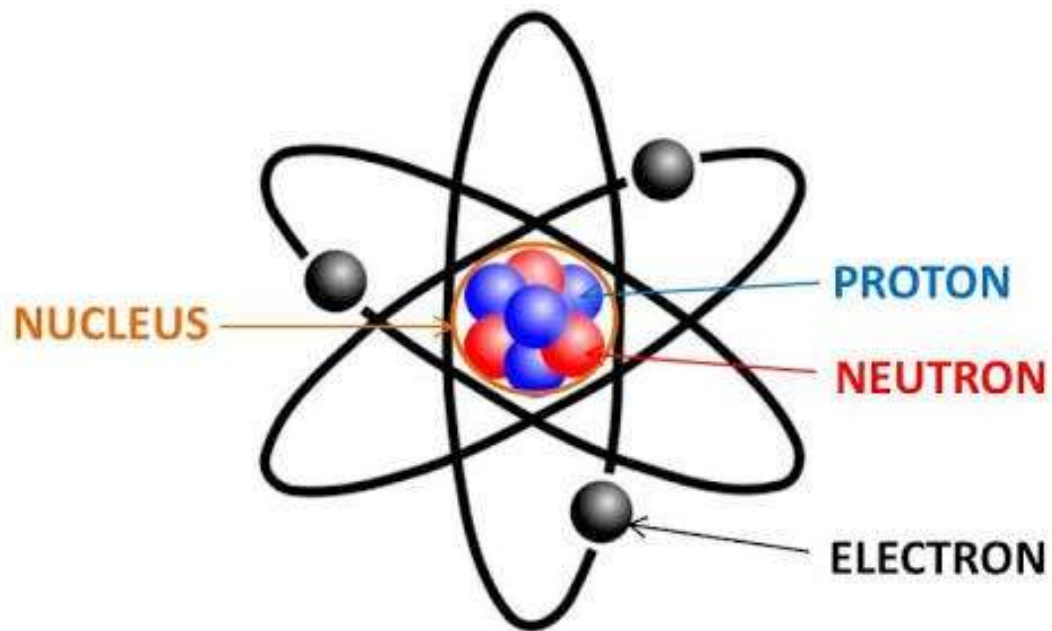
Figure 5 The structure of the atom
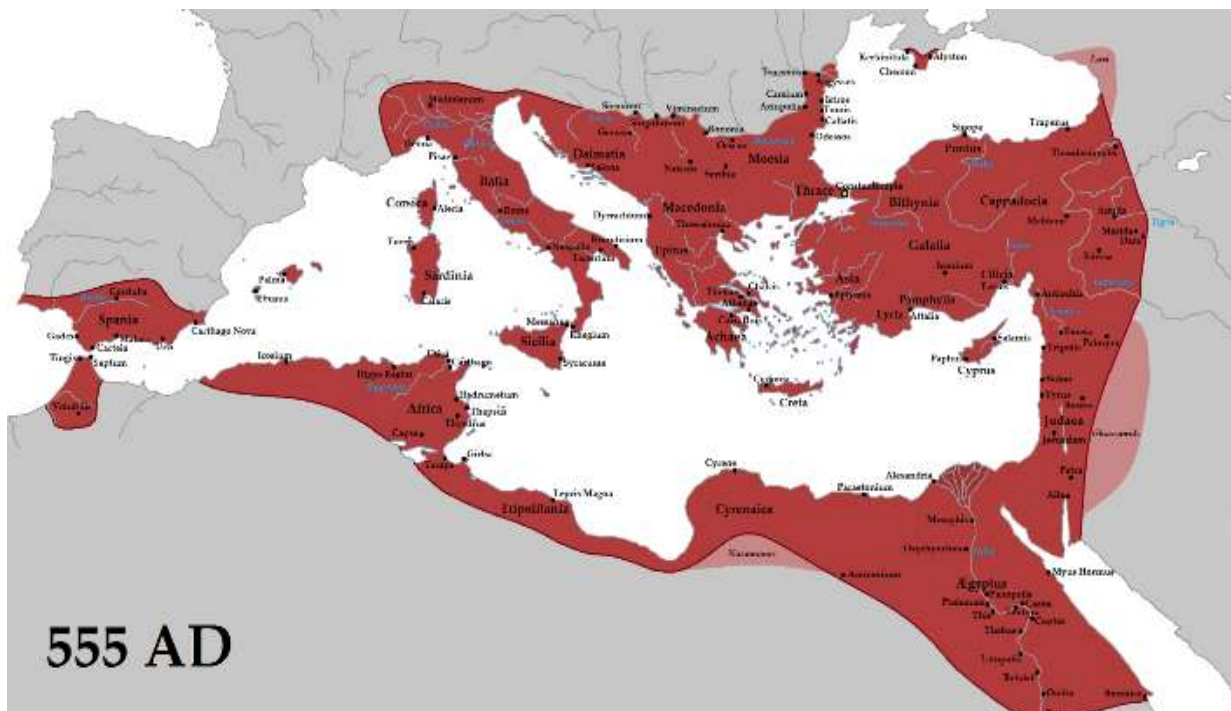
Figure 6 Map of the Byzantine Empire

2.4.7. Accessible mathematical and chemical content

Objective

The main objective was the creation of accessible mathematical and chemical content in different file formats with the use of appropriate tools.

Description

Fifteen mathematical and ten chemical equations were chosen and were written in different file formats such as .docx (MS Word), .pptx (MS Powerpoint), .pdf (Adobe Acrobat), .html and .epub. The chemical formulas were written with Wiris online equation editor, chemtype, then they were copied into a Microsoft Word file. The .docx file created with Microsoft Word, using the program Mathtype from Wiris in order to form the equations. The .ppt file was created with Microsoft Powerpoint. The .pdf file was created from Microsoft Word as an export. The .html file was created with the the Notepad ++ text editor. Lastly the .epub file was created with the program Word to Epub by DAISY. Two different assistive technologies were used in order to evaluate the accessibility of each file, NVDA and JAWS. Also, another program was installed, MathPlayer, which is a universal math reader that enables math to be spoken in assistive technology products.

The mathematical equations in the different formats can be found at "*math.zip*".

The chemical reactions in the different formats can be found at "*chem.zip*"**.**

Development procedure

The developement procedure for each type of material is described bellow.

Mathtype

Mathtype is a graphical equation editor for mathematical equations in Microsoft Word and Powerpoint. It supports the math markup languages TeX, LaTeX and MathML. All the equations were written with Mathtype inside MS Word and Powerpoint. Mathtype was used because EquationEditor which is included in MS Word doesn't work with screen readers.

Mathplayer

Mathplayer is a universal math reader that enables math to be spoken in assistive technology products. Mathplayer is based on MathML technology. MathML is an industry standard way of encoding mathematics using XML developed under the auspices of the W3C (World Wide Web Consortium). Through Mathplayer NVDA and Jaws can read mathematical content, which is written in MathML by Mathtype.

The math and chem content in MS Word and Powerpoint files are easily accessible by assistive technologies because they can read the equations written in MathML.

In the .pdf file, on the contrary, math content can not be read by assistive technology because .pdf files do not render MathML, like MS word files. Until now it seems that there is no authoring environment that allows writing accessible math content inside .pdf files. Simple equations can be

InSIDE project	Page	WP2: Adapted educational material
2018-3218 /001-001	[44|103]	DEV2.1: Development of Educational Materials

rendered inline. However, as soon as any subscript or multilevel equations are used they become unreadable. This can be bypassed by two ways. Either inserting the math equations as images with alternate text or long description (for complex equations) or inserting the math equation as a block with a hyperlink into an .html file which is accessible.

The .html file was created by Notepad ++. The MathML equivalent of each equation was copied through Mathtype. Each browser renders the equations differently. Mozila Firefox and Internet Explorer web browsers render the equation automatically and the assistive technologies can read the equations. Other web browsers like Chrome or Opera need Mathjax, which is a Javascript display engine. NVDA and Jaws worked better with Mozila Firefox.

The .epud files has the same problems as the .pdf files. Neither .Mathml nor .svg files are currently viable equation formats for ebooks due to widly inconsistent rendering support across the ereader ecosystem. The same solution as the .pdf files can be used. Either inserting the math equations as images with alternate text or long description (for complex equations) or inserting the math equation as a block with a hyperlink into an .html file which is accessible.

The .html file that opens from the .pdf and epub files can be stored locally at the computer that has the file or can be stored in a server and accessed by a website.

The transcript of NVDA and Jaws was written in an extra word file. Also, the mathematical equations were translated to Nemeth code.

2.4.8. Tactile Graphics

Objective

Graphics are not usually accessible by individuals with blindness but contain important educational information. The main objective was the production of tactile graphics, which include images, diagrams and maps that are accessible by individuals with blindness. An additional goal was to highlight methods and techniques for developing the tactile graphics.

Description

The selected graphics come from various fields such as physics, medicine, mathematics, engineering, art, history, biology, botany, geography, social science. We can not cover all scientific areas but we can show the importance of tactile graphics in the education of individuals with blindness. During the on-screen digitizing there is some generalization of each image. This happens so that the individuals with visual impairments can perceive the important information of each image. The chosen images are the following:

- The structure of the atom
- Bar-chart 1
- Brain
- Map of the Byzantine Empire
- The Persistence of Memory
- Diagram of Major Milestones of Brain Development
- Diagram of Risk of Down Syndrome and all chromosomal abnormalities by maternal age
- The Discobolus of Myron
- Concept map

- Eye Anatomy
- Flow chart
- The great sphynx
- Inductor
- Magnetic field
- Plant
- Scatter
- Geometric shapes
- Bar chart 2
- Line chart
- Pie chart

The first step of creating the tactile images is the on-screen digitizing of the chosen images. On screen digitizing is the drawing of vector objects on top of the image and filling them with different surfaces where it is necessary. For this purpose, Adobe Illustrator software was used, which is a vector graphics editor and design program. After digitizing, the images were exported in .jpeg or .png format and then printed on microcapsule paper with a classic printer. Later the printed images were passed through the PIAF tactile image maker and the tactile images were produced. Additionally, the same images where converted into tactile images with a different method. The Viewplus Designer software and the Tiger pro gen II embosser were used in order to produce embossed tactile images. These are included in the Tiger Software Suite (TSS).

The files are located at "*Tactile Pictures and Charts.zip*".

Development procedure

As stated above the tools that were used where the Adobe Illustrator and Viewplus Designer software and the Tiger Pro Gen II Embosser. Adobe Illustrator offers a variety of tools that are broadly organized in the following categories:

- Select

- Draw

- Type

- Paint

- Modify

- Navigate

These tools were used for drawing the vector objects on top of the images. Every image was processed in order to maintain most of the information from the original image but also be easily perceived by individuals with visual impairment.

Viewplus Designer software can process files with the .prn format. These files are created by the driver of Tiger Embosser. The Viewplus Designer, in contrast with Adobe Illustrator, processes the images with raster graphics and contains a variety of simple tools. The Embosser software driver

converts the colors of the original image into seven different shades from one to seven. These shades translate into different dot sizes when the image is embossed by the Tiger embosser.

An extra add-on is installed in the Microsoft Word when the TSS is installed, the Tiger add-on. This add-on allows the conversion of text into braille and mathematical equations into Nemeth code.

The structure of the Atom

The image of the structure of the atom was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. Then the vector lines were drawn on top of the original image. The protons, electrons and neutrons where designed with different texture. The text was converted into English, French and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
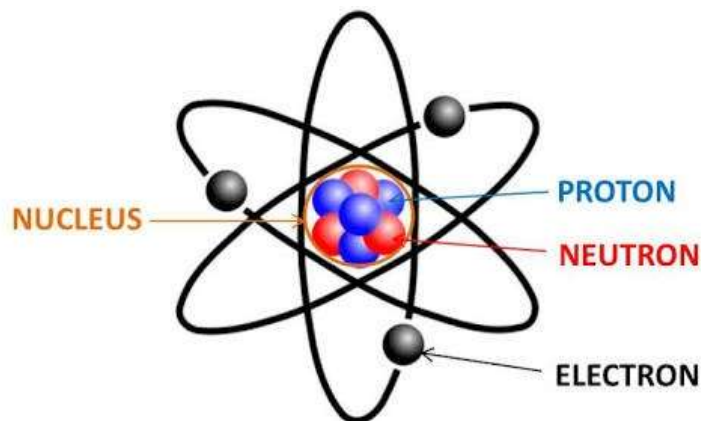

Figure 7 The structure of the atom - The original image
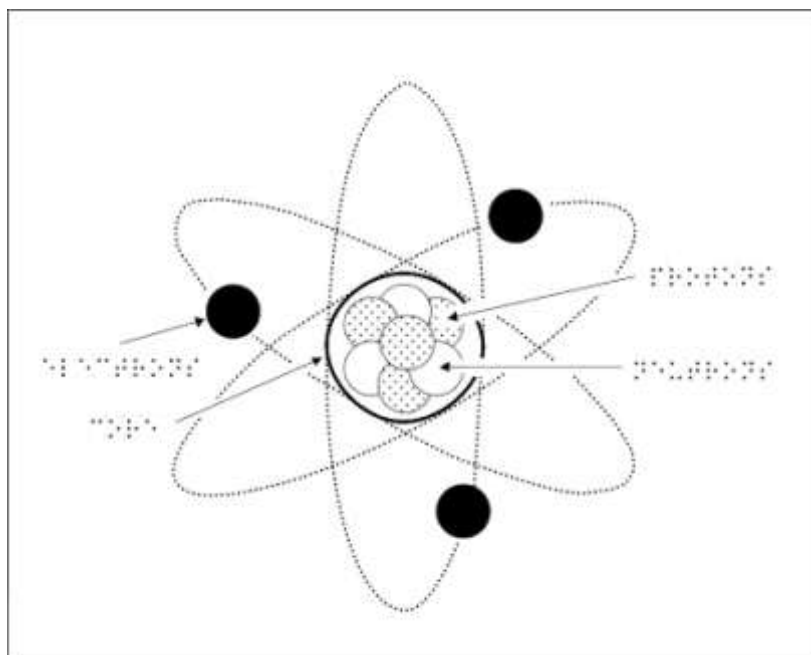
Figure 8 The structure of the atom - Tactile image
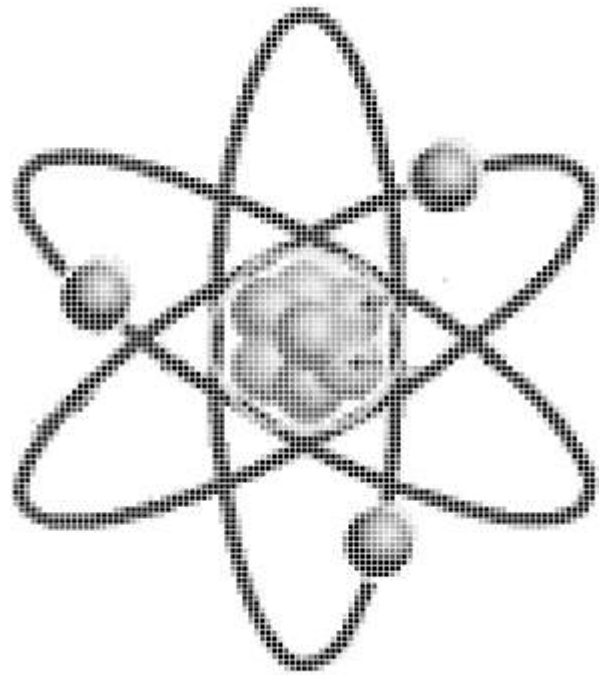
Figure 9 The structure of the atom - Automatic export of the tiger embosser from the original image
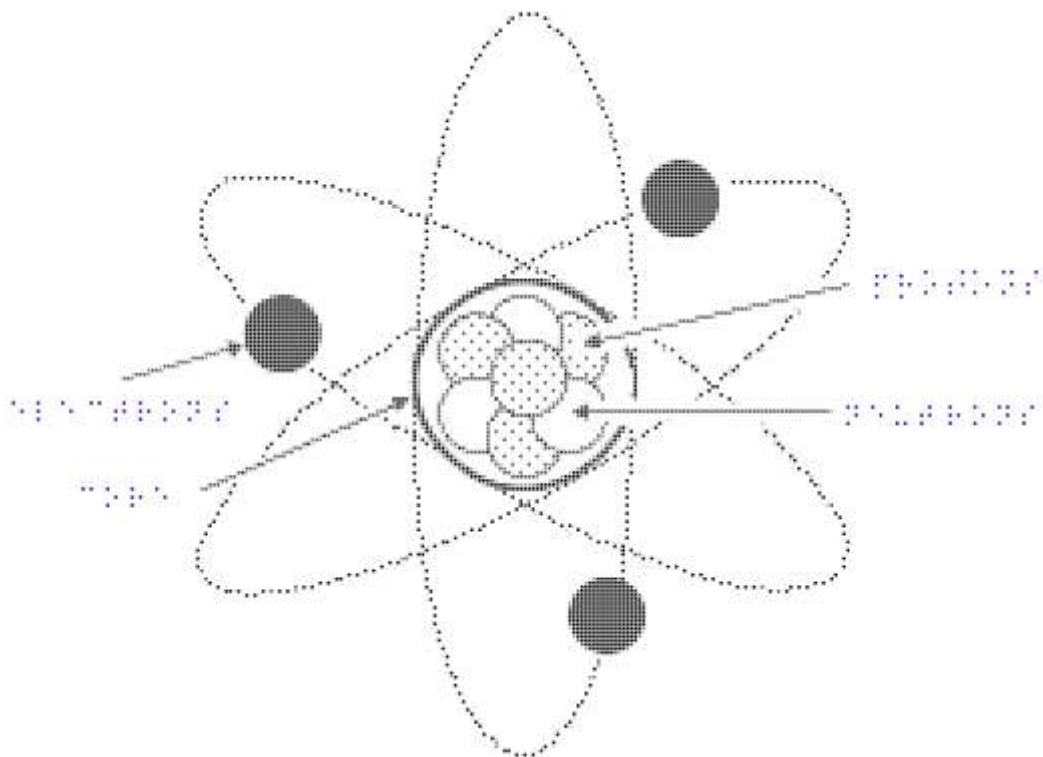
Figure 10 The structure of the atom - Tactile image printed with tiger embosser
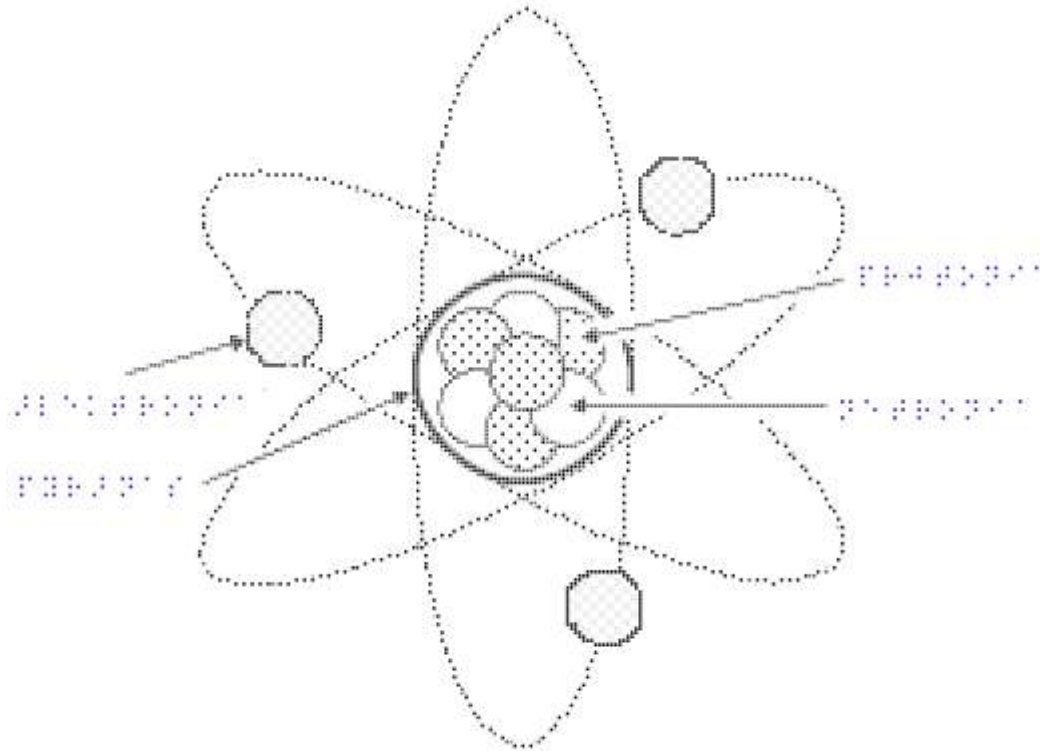
Figure 11 The structure of the atom - Tactile image printed with tiger embosser

Bar-chart 1

The image of a bar chart with excuses for being late was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form.The bars where digitized as vector objects. The text was moved to the bottom of the image in order to fit the printing paper better. The text was converted in English and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
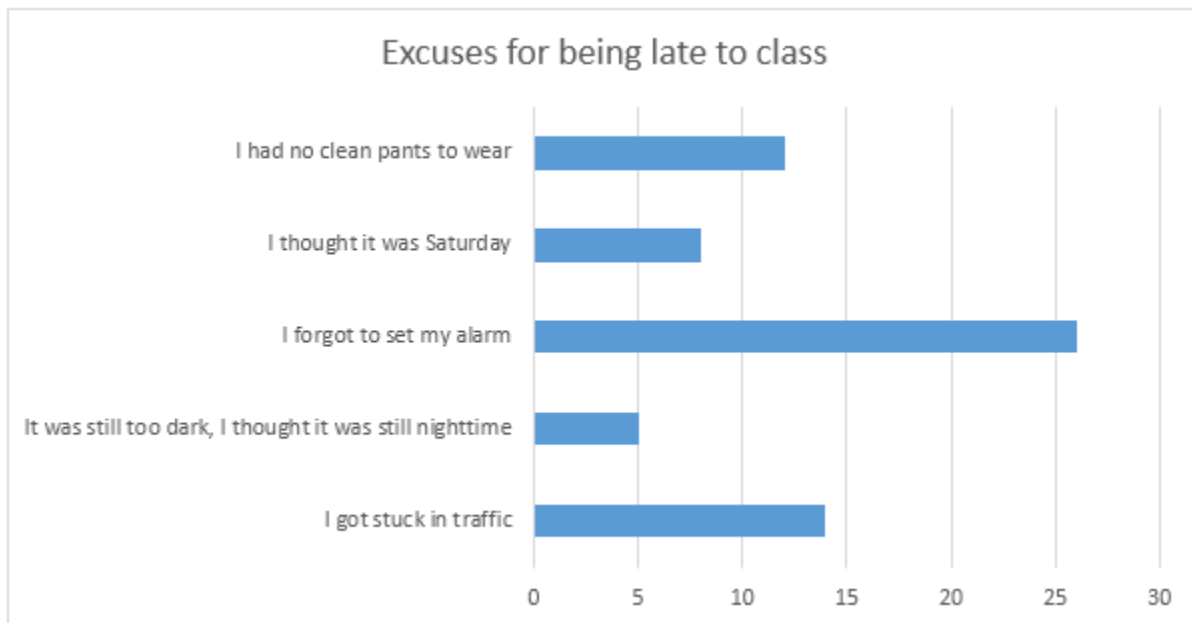
Figure 12 Bar-chart 1 - The original image
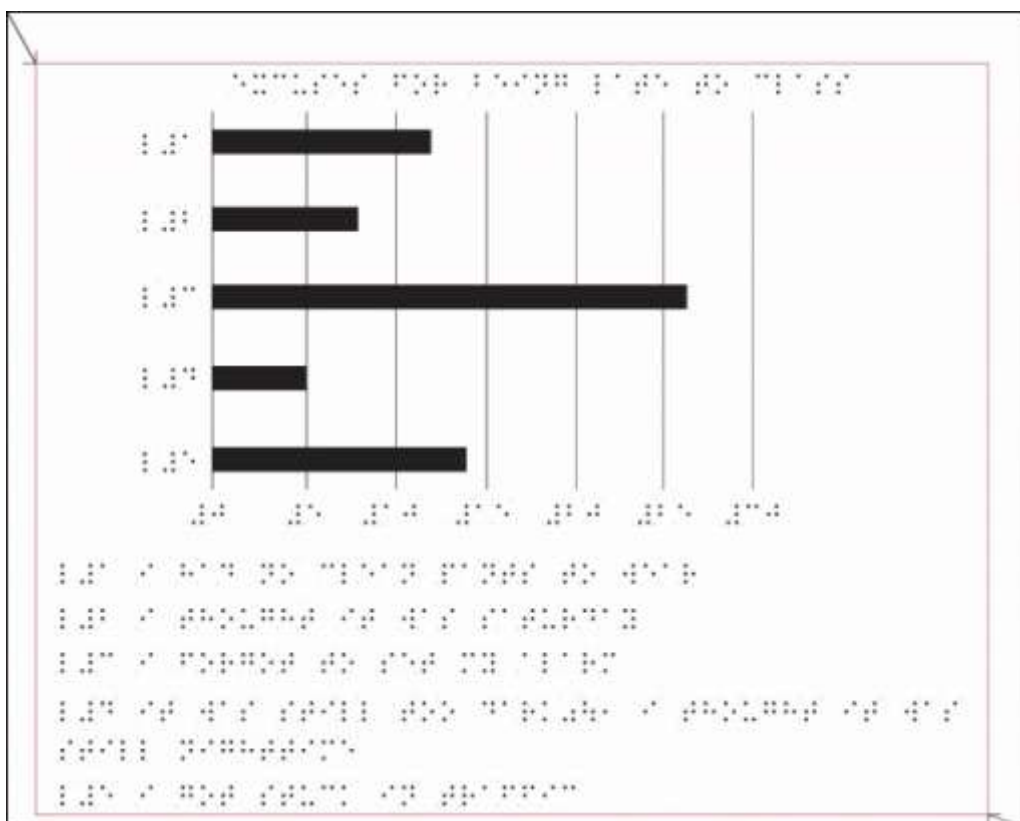
Figure 13 Bar-chart 1- Tactile image

Figure 14 Bar-chart 1- Tactile image printed with tiger embosser

Brain

The image of the human brain was digitized . The different parts of the brain were drawn on top of the original image. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The text was converted to English, French and Greek braille. Due to the fact that the braille text did not fit into the image, numbers where put in every part of the brain and a separate file was printed as a picture key in order to explain each number. How each number correspond to the text is shown below.

1 optical cortex

2 occipital lobe

3 parietal lobe

4 temporal lobe

5 acoustic cortex

6 body sensation

7 body movement and coordination

8 frontal lobe

9 prefrontal lobe
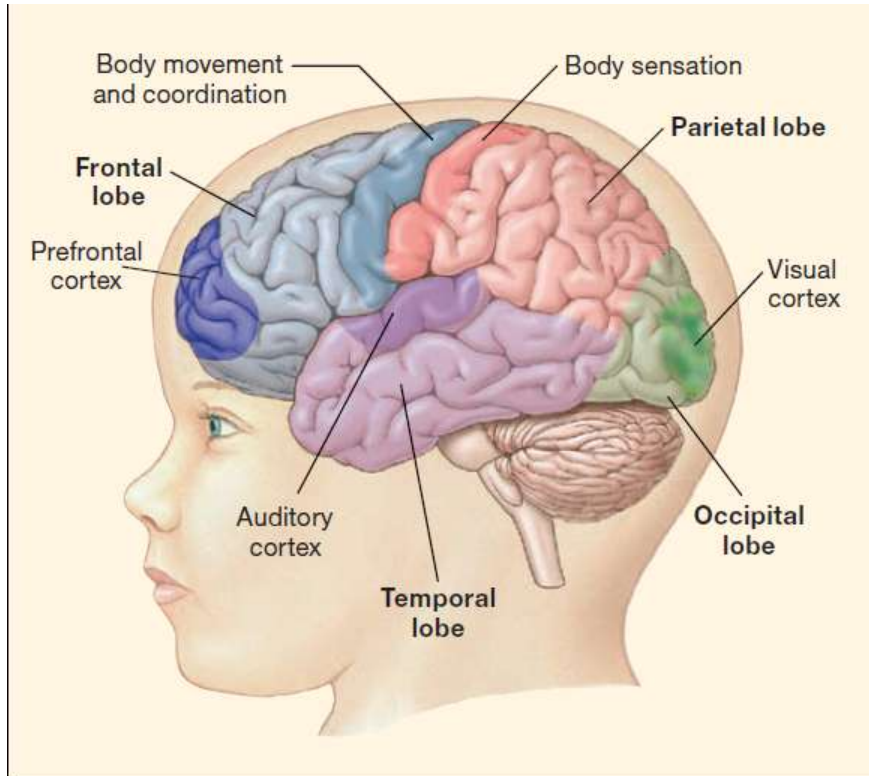
Figure 15 Brain - The original image
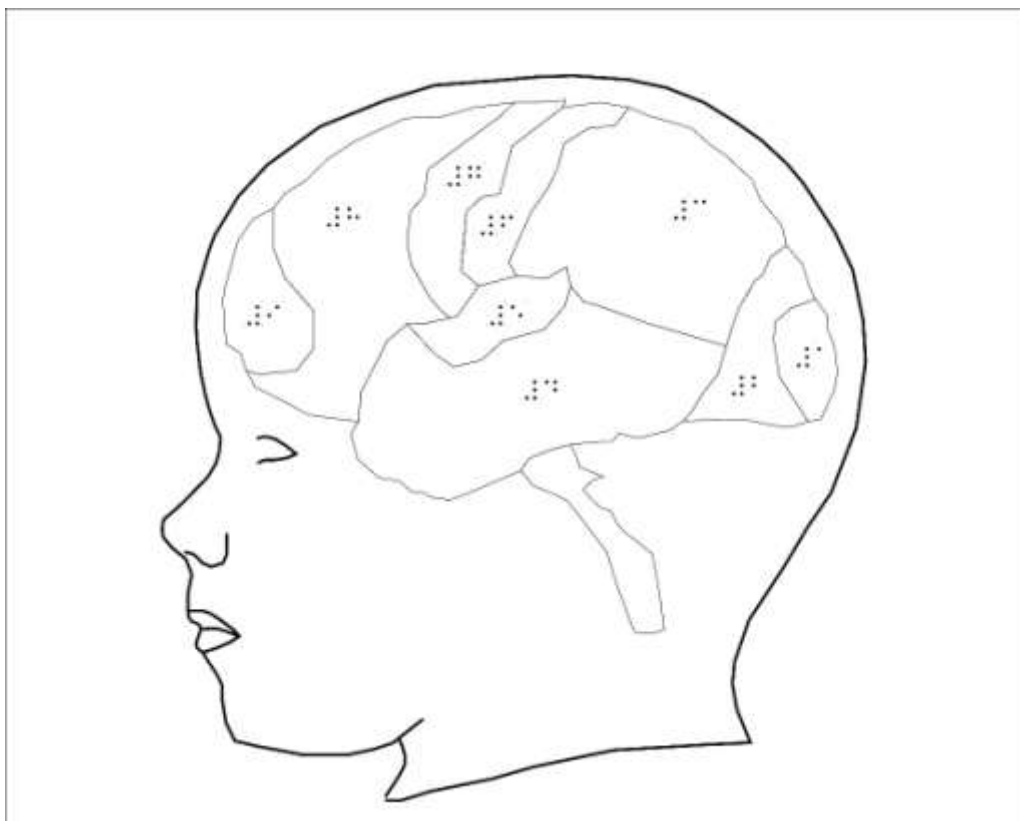
Figure 16 Brain - Tactile image
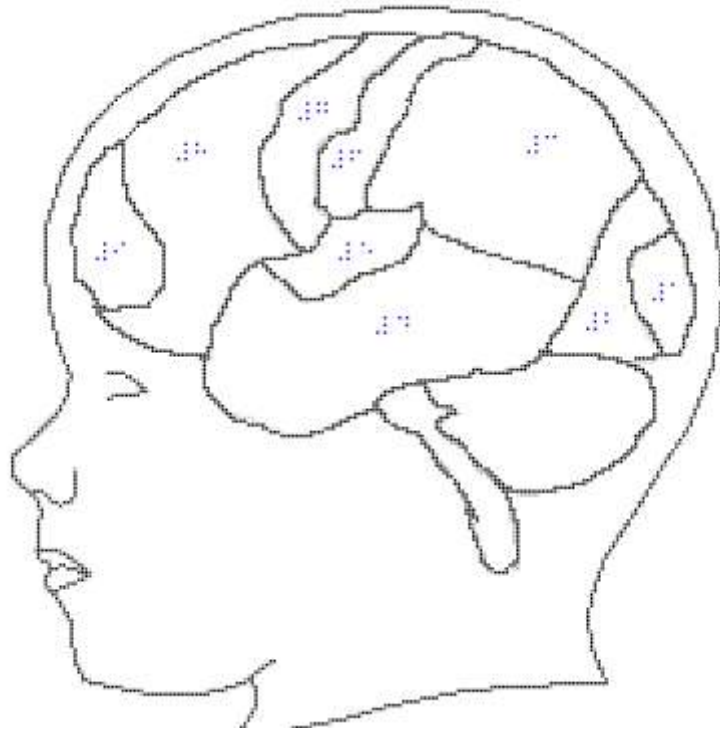
Figure 17 Brain - Tactile image printed with tiger embosser

A map of the Byzantine Empire

The image oft he Byzantine Empire was digitized. The regions where drawn on top of the original image. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The cities where written in English and Greek braille language. There was some generalization performed, meaning that some cities where left out because they could not fit into the image. Different texture was applied to the different areas. The same principle as the brain was followed meaning that numbers where put in each city and an extra file as a picture key was printed in order to explain each number. How each number correspond to the text is shown below.

1 constantinople

2 rome

3 macedonia

4 odessos

5 dyrachium

6 ephesus

7 iconium

8 antiochia

9 jerusalem

10 cyprus

11 aegiptus

12 alexandria

13 memphis

14 latopolis

15 cyrenaica

16 cyrene

17 creta

18 lepsis magna

19 africa

20 spania

21 tingis

22 sicilia

23 sardinia

24 italia

25 pontus

26 cappadocia

27 bithynia

28 dalmatia

29 galatia

The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
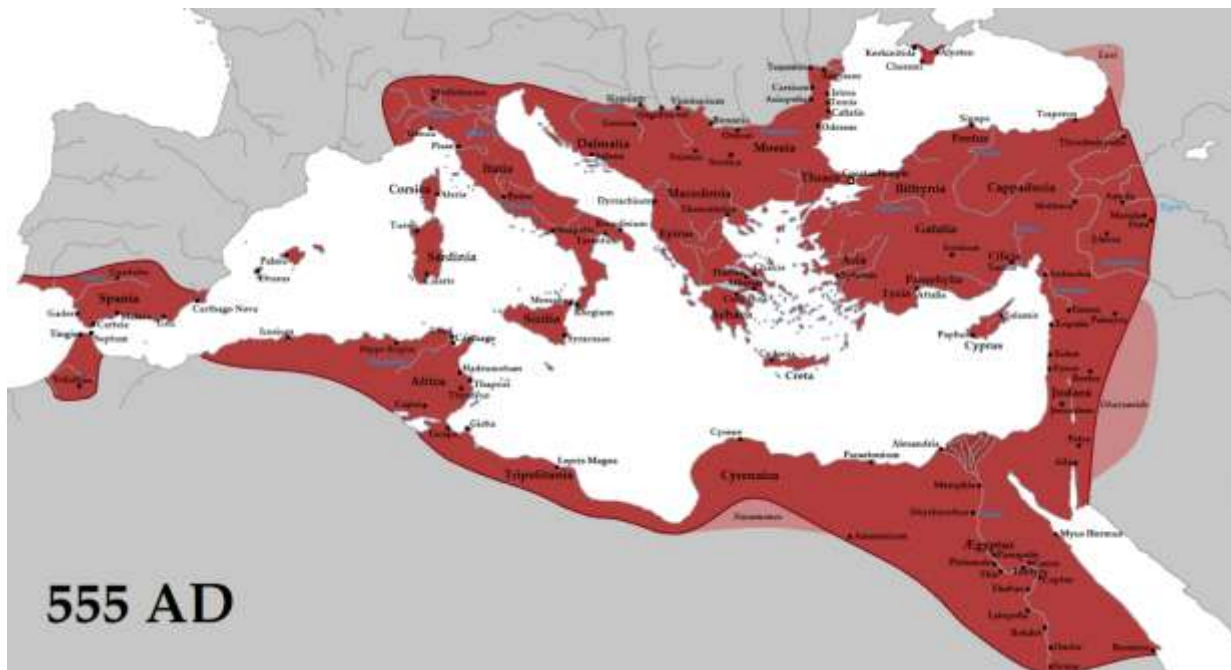
*Figure 18 Map of Byzantine empire - The original image*
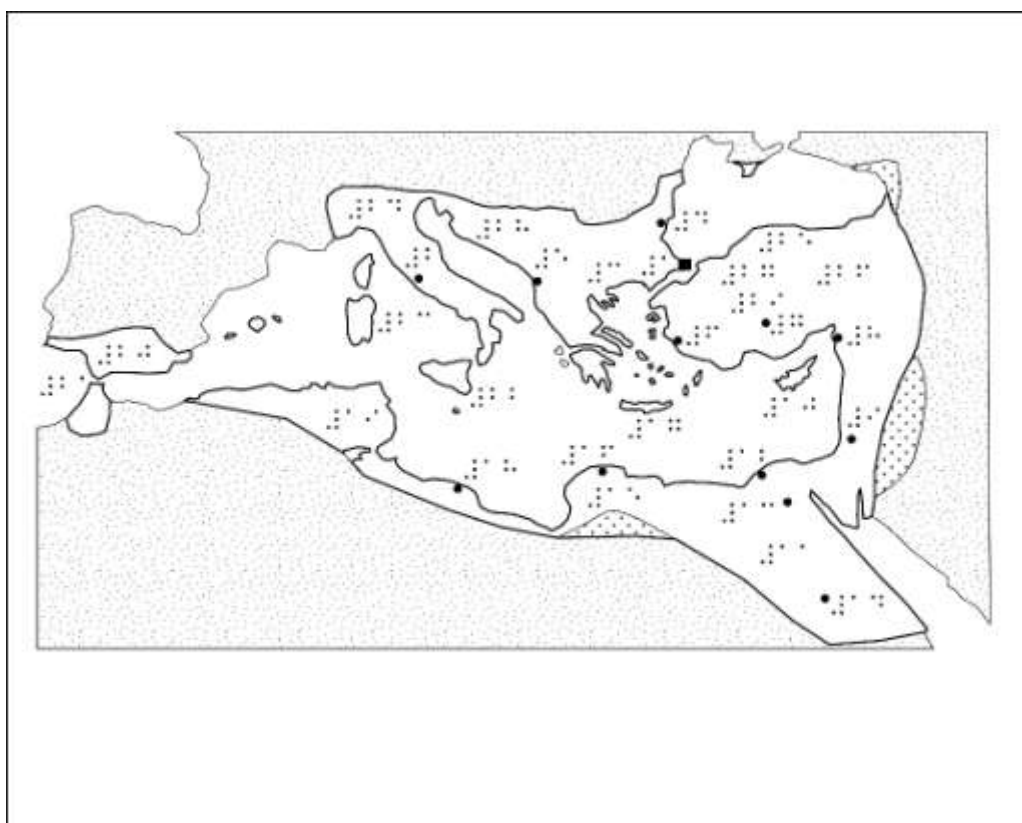
Figure 19 Map of Byzantine empire - Tactile image
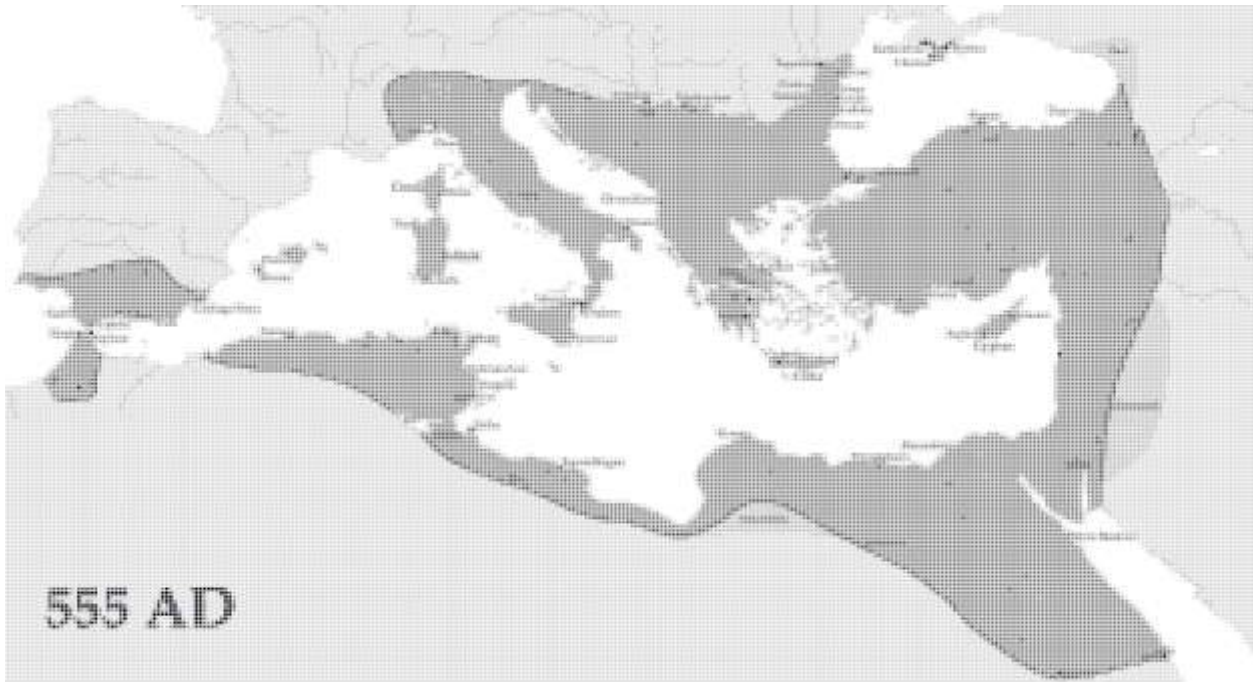
Figure 20 Map of Byzantine empire - Automatic export of the tiger embosser from the original image
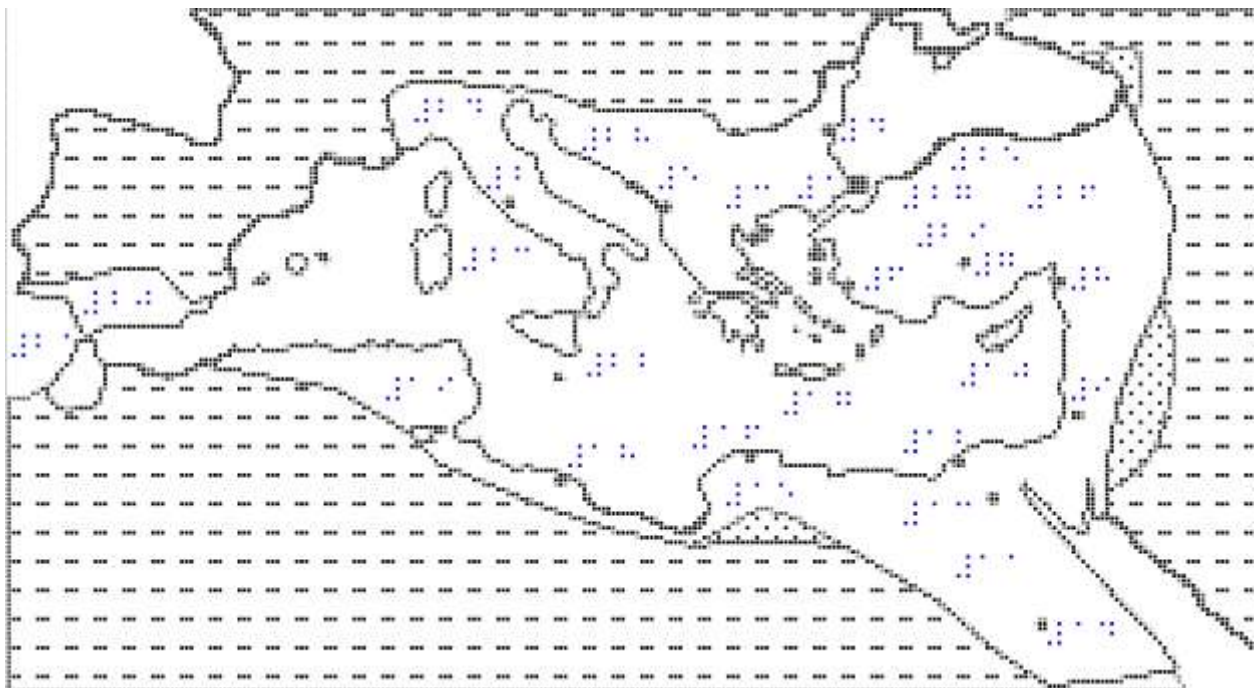
Figure 21 Map of Byzantine empire - Tactile image printed with tiger embosser

The image of the famous painting by Salvador Dali "The Persistence of Memory" was digitized . On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. New vector objects where drawn above the original image. Also, different texture was applied on the surfaces in order to make them easier to distinguish and be perceived. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.

Figure 22 The Persistence of Memory - The original image
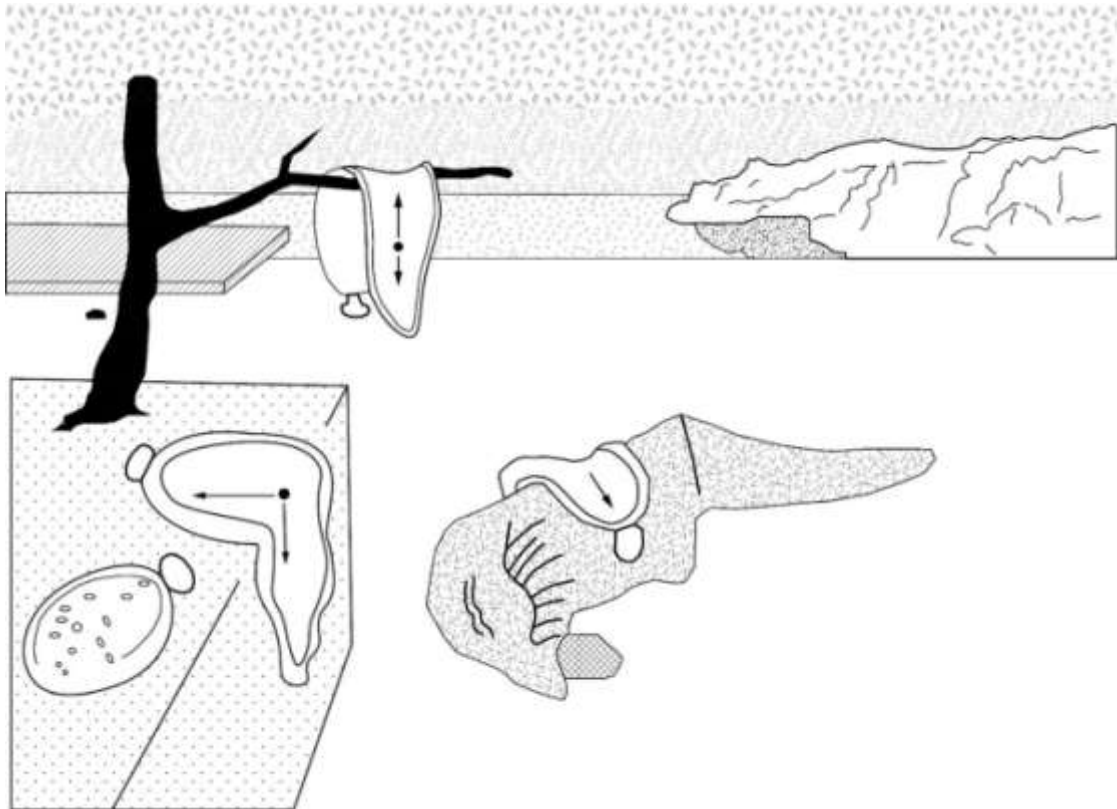
Figure 23 The Persistence of Memory - Tactile image
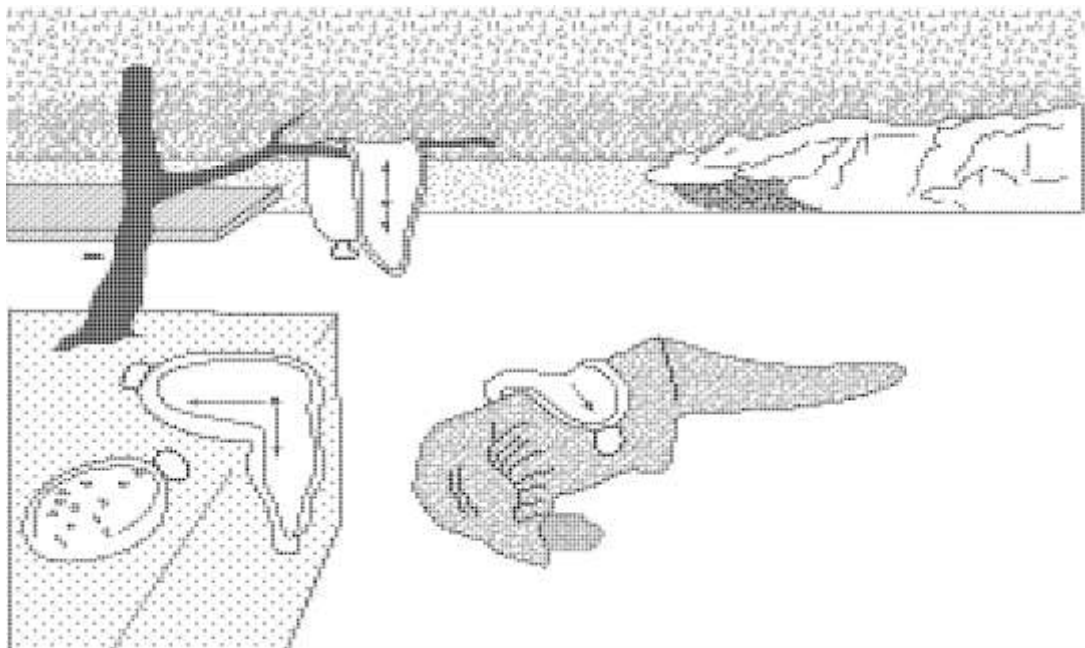
Figure 24 The Persistence of Memory - Tactile image printed with tiger embosser

Major milestones of brain development

The image of major milestones of brain development was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form.The vector lines were drawn on top of the original image. For each line of the diagram different texture was used. Some generalization was performed in order to fit all the necessary information in the image. Also, the text that was inside the diagram was replaced by numbers and an additional file, which explains each number, was printed in braille and was used as a picture key. The text was converted in English ang Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.

The numbers in the diagram correspond to the following

1. Production and migration of neurons
2. Myelination
3. The rapid formation of synapses is followed by synaptic pruning
4. Adult levels of synapses
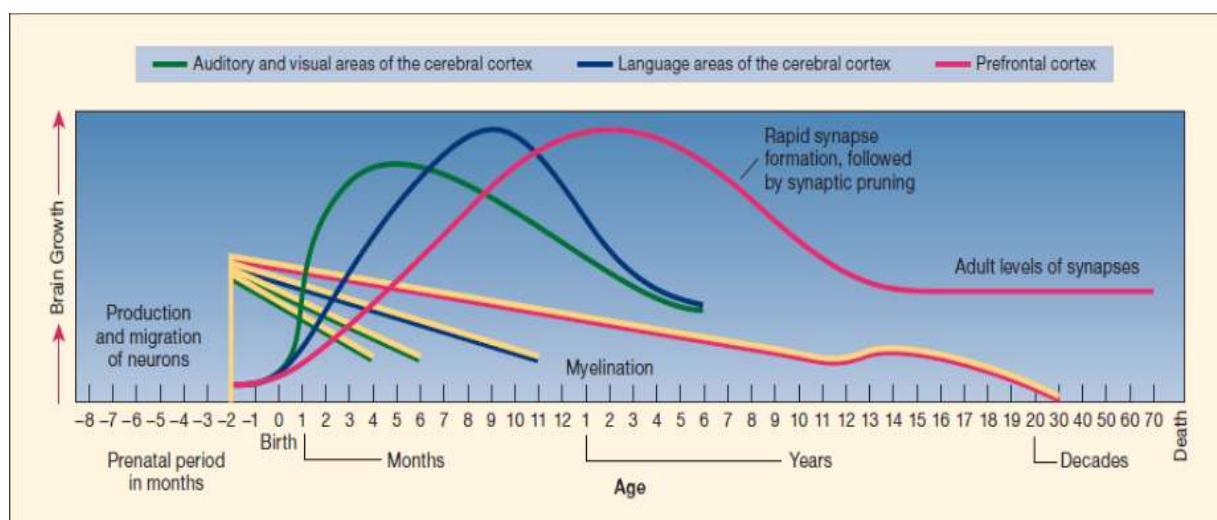
Figure 25 Major milestones of brain development - The original image
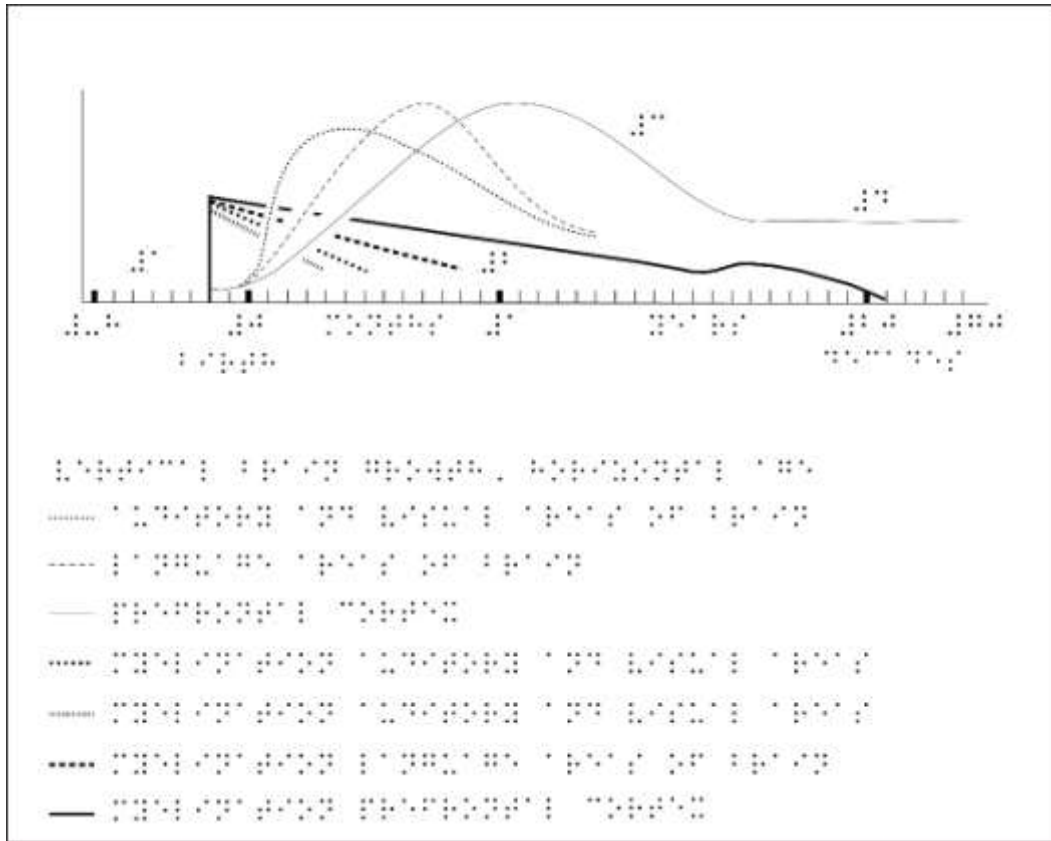
Figure 26 Major milestones of brain development - Tactile image
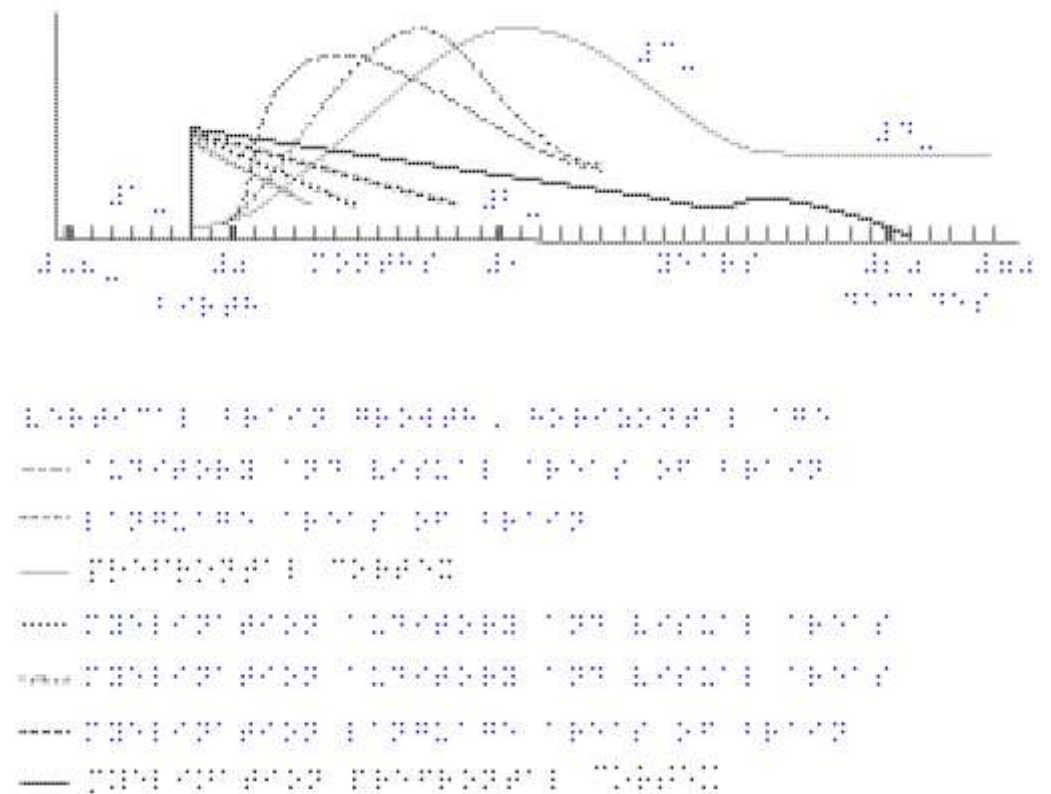
Figure 27 Major milestones of brain development - Tactile image printed with tiger embosser

Risk of Down Syndrome and all chromosomal abnormalities by maternal age

The image of a chart of Risk of Down Syndrome and all chromosomal abnormalities by maternal age was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form The vector lines were drawn on top of the original image. The text was converted in English, French and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
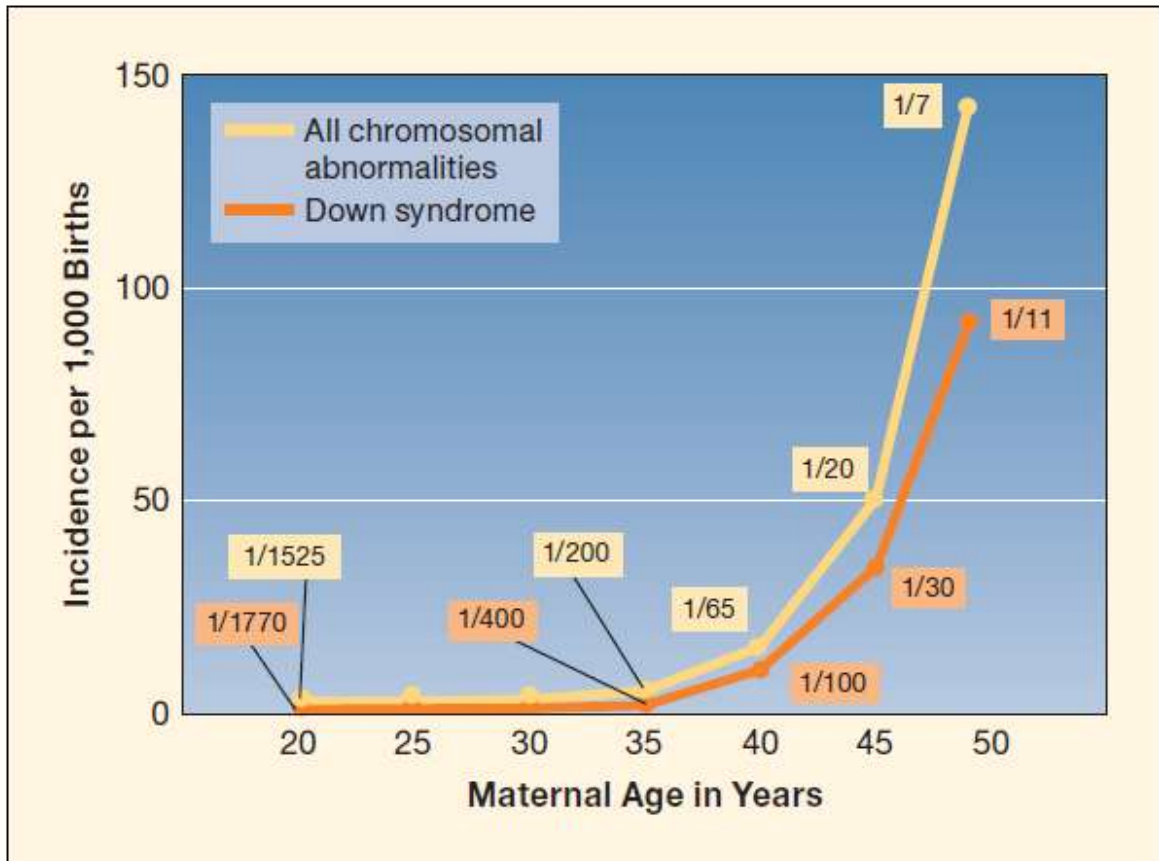
Figure 28 Risk of Down Syndrome and all chromosomal abnormalities by maternal age - The original image
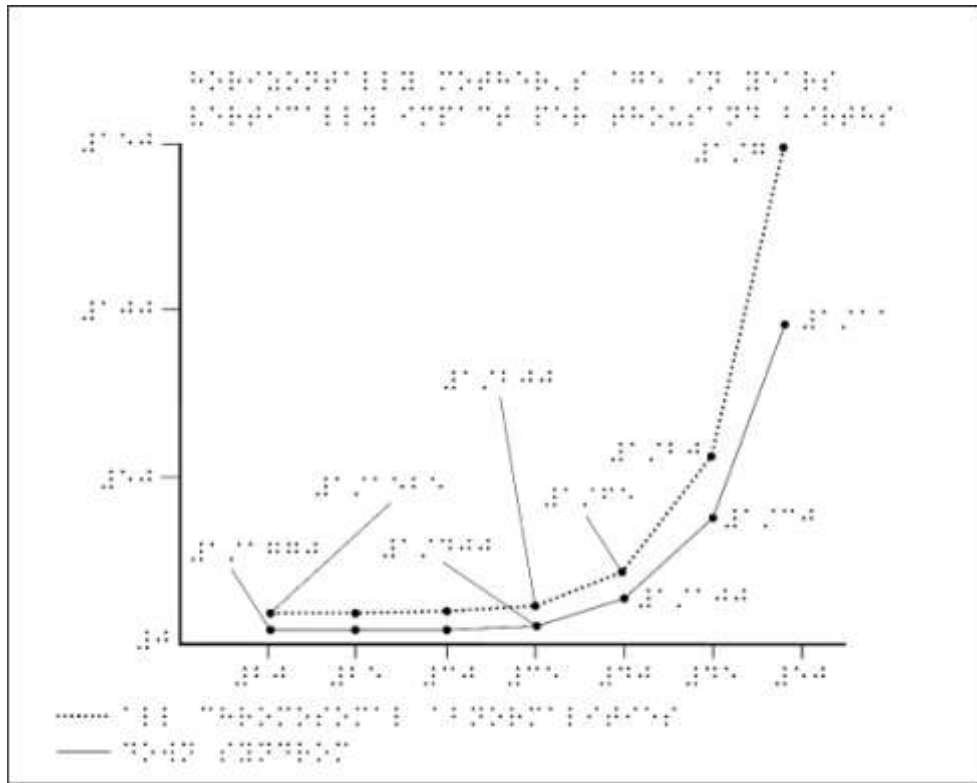
Figure 29 Risk of Down Syndrome and all chromosomal abnormalities by maternal age development - Tactile image
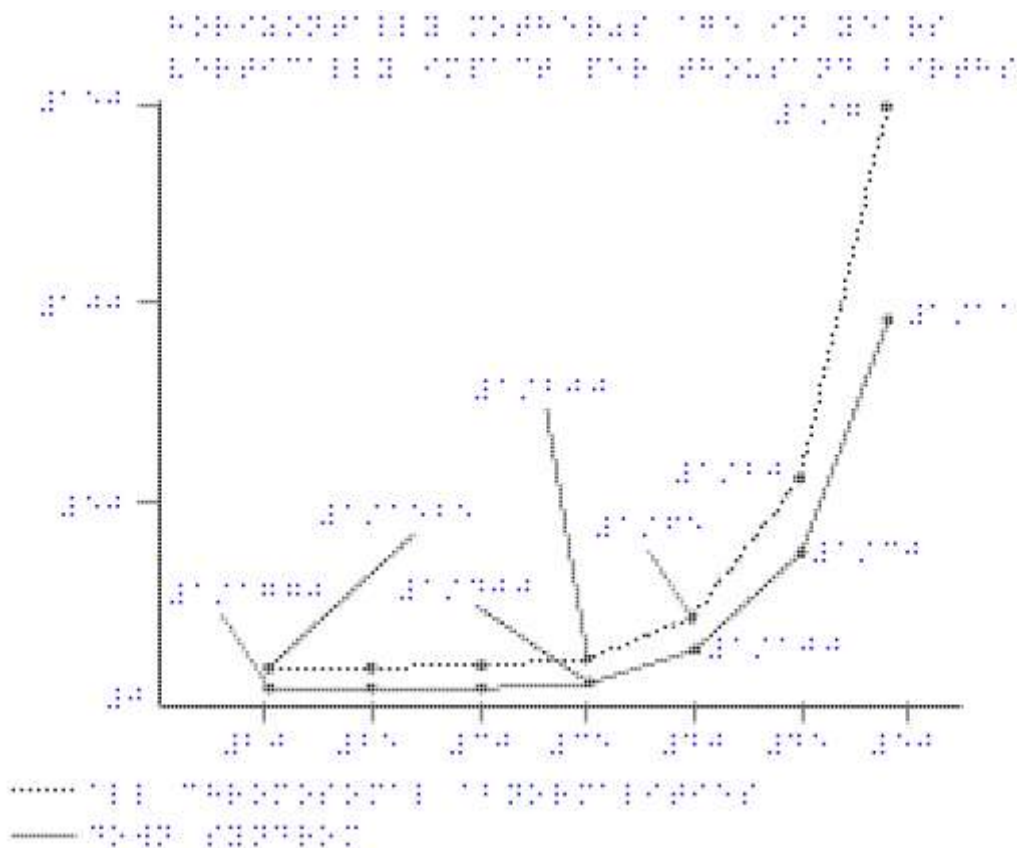
Figure 30 Risk of Down Syndrome and all chromosomal abnormalities by maternal age - Tactile image printed with Tiger embosser

The discobolus of Myron

The image of the famous sculpture of Discovolus of Myron was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The vector lines were drawn on top of the image. Different texture was placed in the different areas. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.


Figure 31 The discobolus of Myron - The original image

Figure 32 The discobolus of Myron - Tactile image

Figure 33 The discobolus of Myron - Tactile image printed with Tiger embosser

Concept map

The image of a concept map of weather elements was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The vector lines were drawn on top of the original image but each section had to be rearranged so that all the text could fit. The text was converted into English and Greek Braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
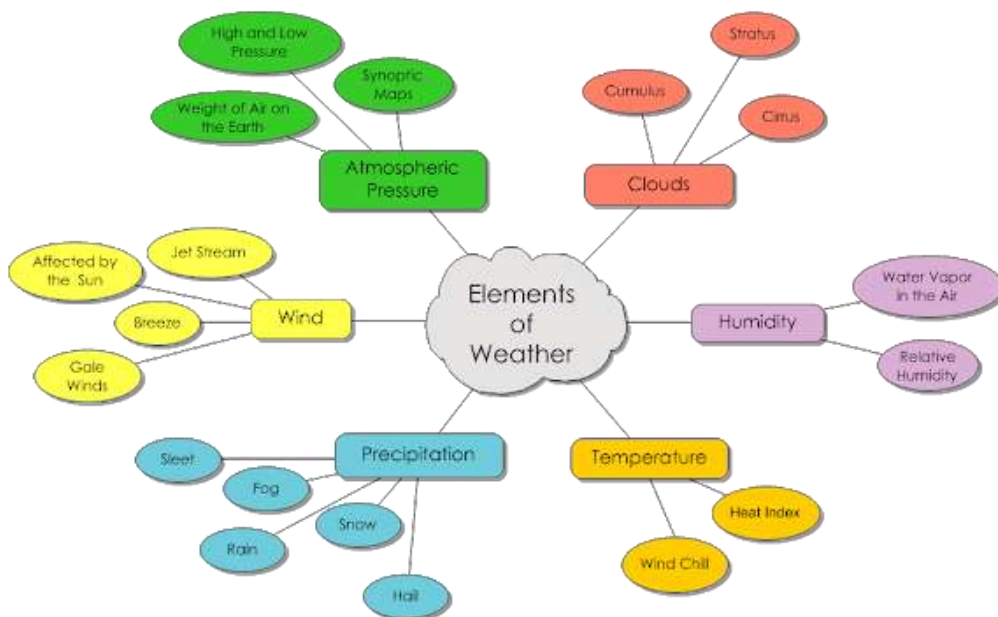
Figure 34 Concept map - The original image
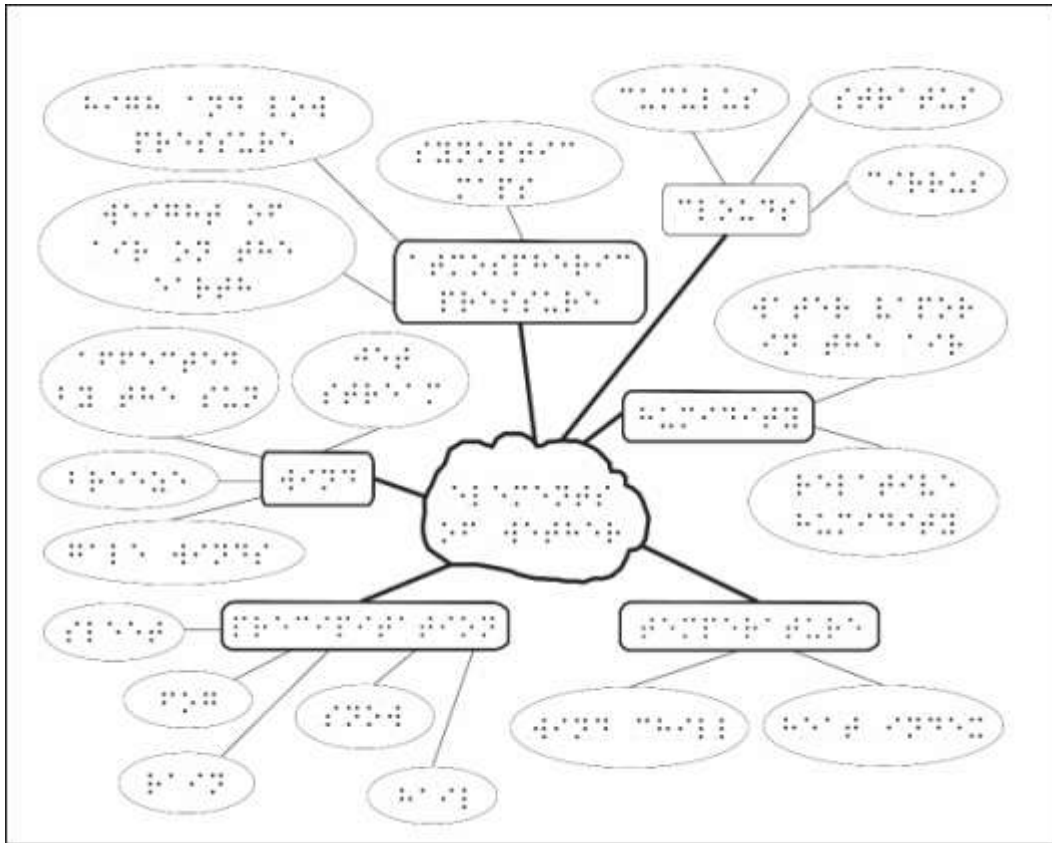
Figure 35 Concept map - Tactile image
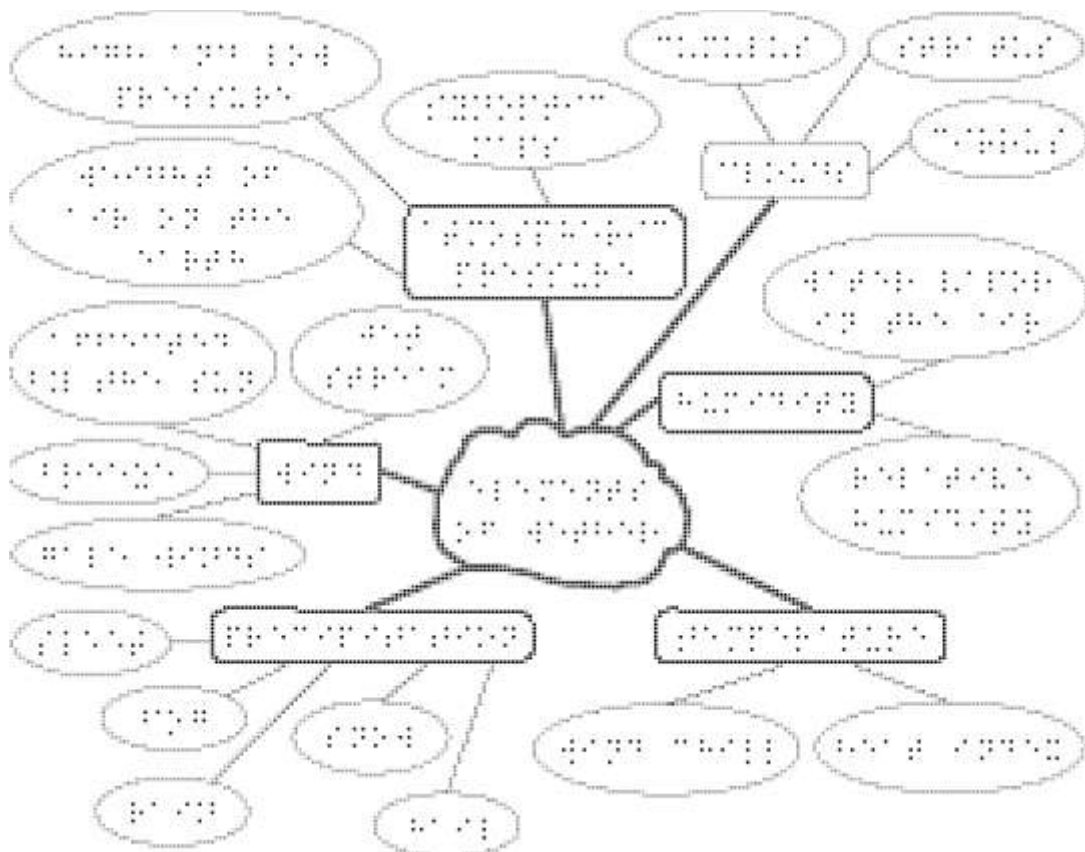
Figure 36 Concept map - Tactile image printed with Tiger embosser

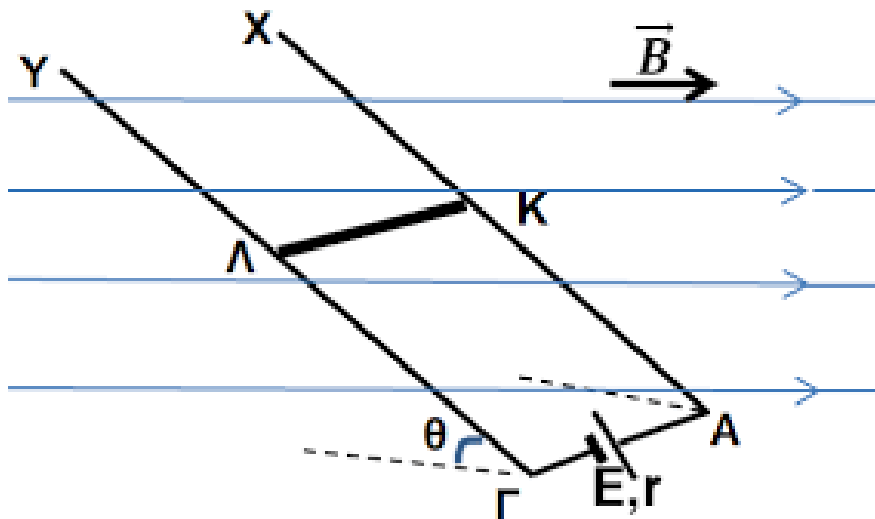| **InSIDE** project	Page	WP2: Adapted educational material
2018-3218 /001-001	[65|103]	DEV2.1: Development of Educational Materials

Eye anatomy

The image oft he human eye anatomy was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The vector lines and objects were drawn on top of the original image. Different texture was placed in different areas. The text was converted in English, French and Greek braille. Due to the fact that the braille text didn't fit into the image, numbers where put in every part of the eye and a separate file as a picture key was printed in order to explain each number. How each number correspond to the text is shown below.

1 vitreous gel (body)

2 choroid

3 optic nerve

4 macula

5 fovea

6 retina

7 superior rectus muscle

8 iris

9 anterior chamber

10 cornea

11 pupil

12 lens

13 ciliary body and muscle

14 inferior rectus muscle

The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
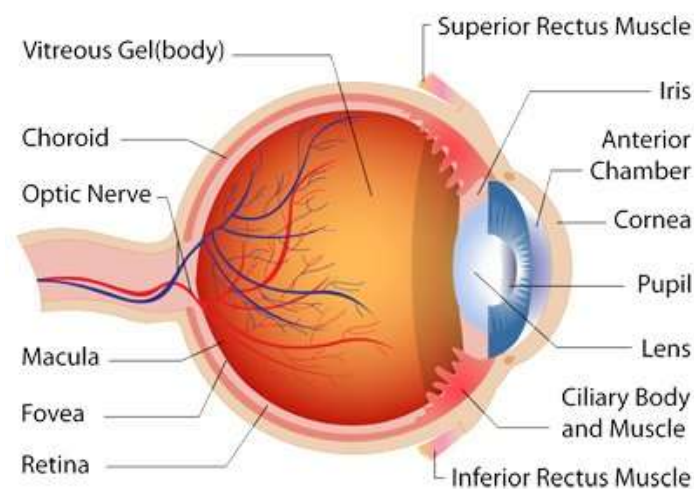
Figure 37 Eye anatomy - The original image
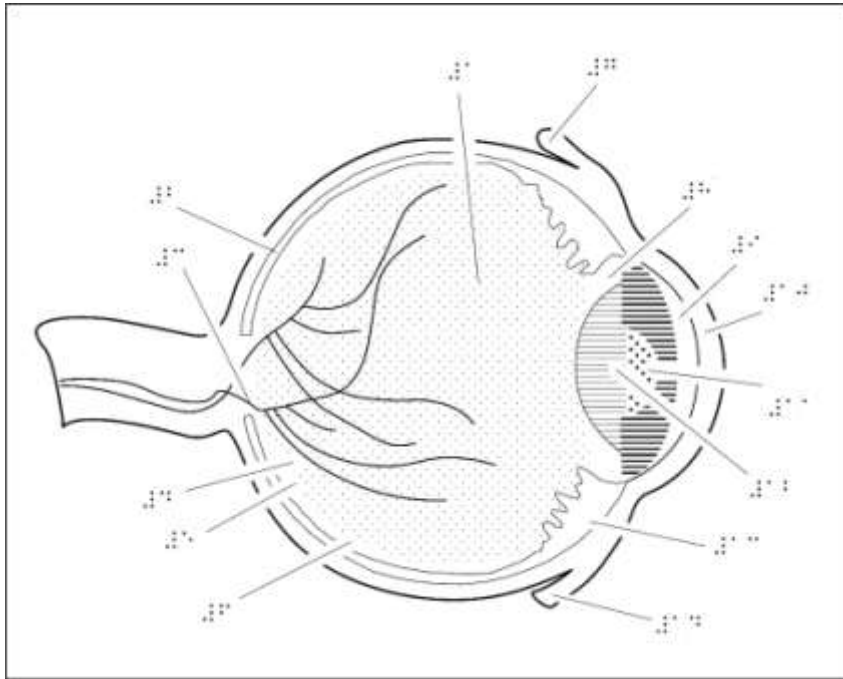
Figure 38 Eye anatomy - Tactile image

Image 1
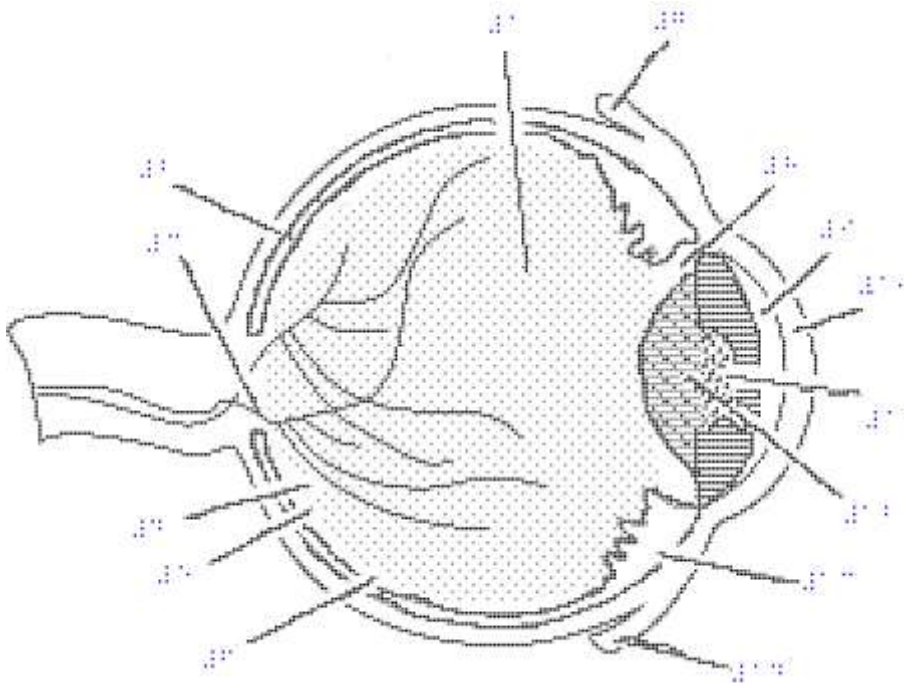
Figure 39 Eye anatomy - Tactile image printed with tiger embosser

Flow chart

The image of a flow chart of a math equation solution was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form.The shapes and lines were drawn on top of the original image. The text was converted in English and Greek braille. Due to the fact that the braille text didn't fit into the image, numbers where put in every part of the flow chart and a separate file was printed as a picture key in order to explain each number. How each number correspond to the text is shown below.1 declare variables a , b , c and d , declare x1 and x2

2 read the values for a , b , and c

3 is $a = 0$?

4 display, not quadratic

5 $d = b^2 - 4 * a * c$

6 is $b = 0$?

7 $a = 0 \ \ b = 0$ bye

8 $x1 = -c \div b$

9 display the answer, x1

10 is $(d) < 0$

11 display no real answer fail to take the square root of negative value

12 root 1 : $x1 = (-b + \sqrt{d}) \div (2 * a))$

13 root 2 : $x2 = (-b - \sqrt{d}) \div (2 * a)$

14 display the roots the two roots, x1 and x2

The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
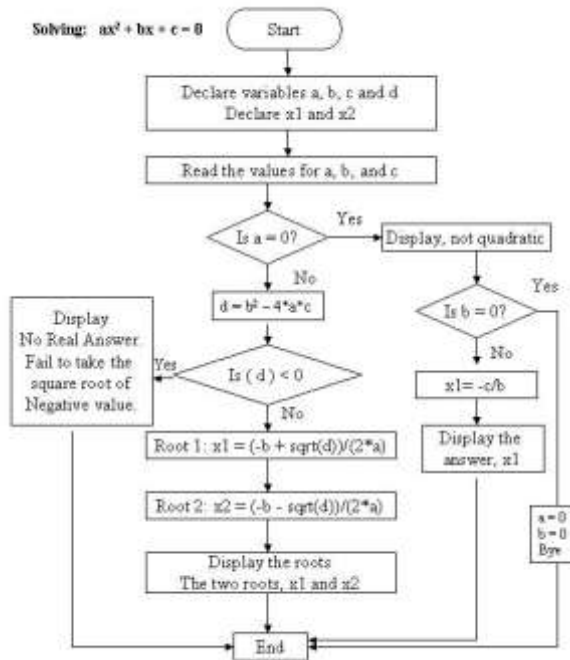
*Figure 40 Flow chart - The original image*
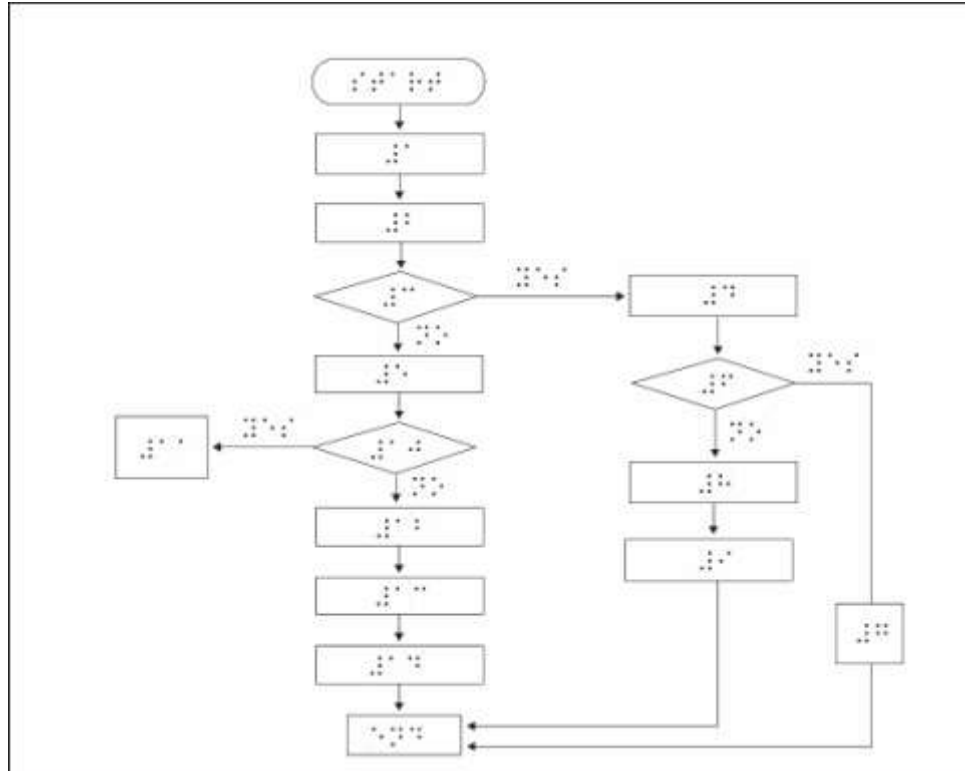
Figure 41 Flow chart - Tactile image
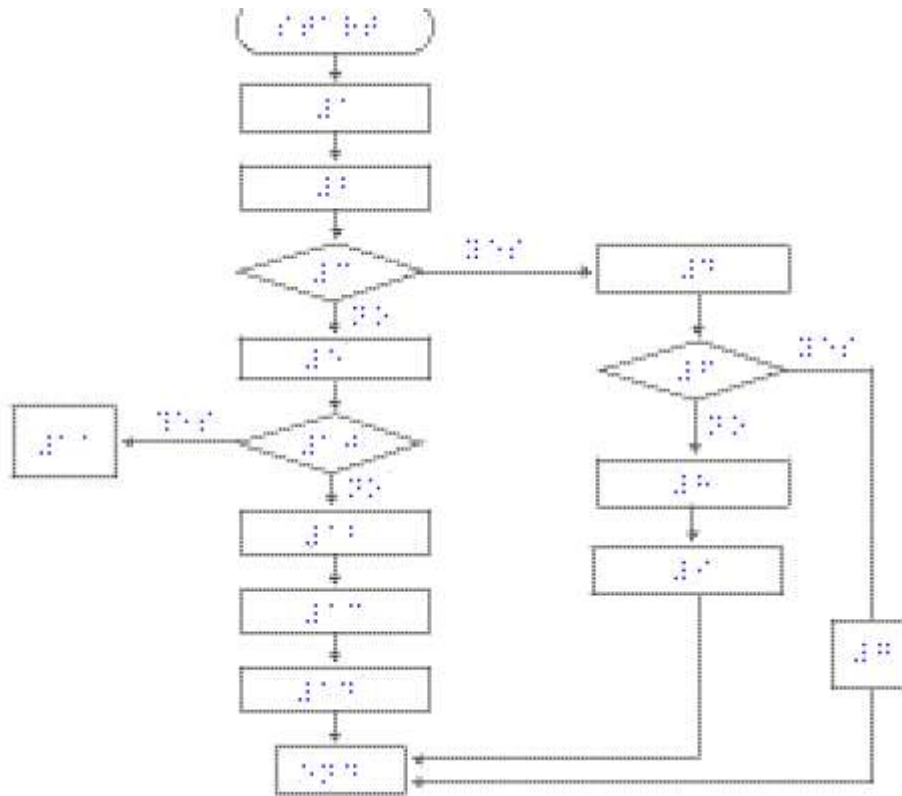
Figure 42 Flow chart - Tactile image printed with Tiger embosser

The Great Sphynx

The image oft he Great Sphynx was digitized Great Sphynx. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The vector shapes were drawn on top of the original image and different texture was places on different areas. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.

Figure 43 The great sphynx- The original image

InSIDE project	Page	WP2: Adapted educational material
2018-3218 /001-001	[70|103]	DEV2.1: Development of Educational Materials
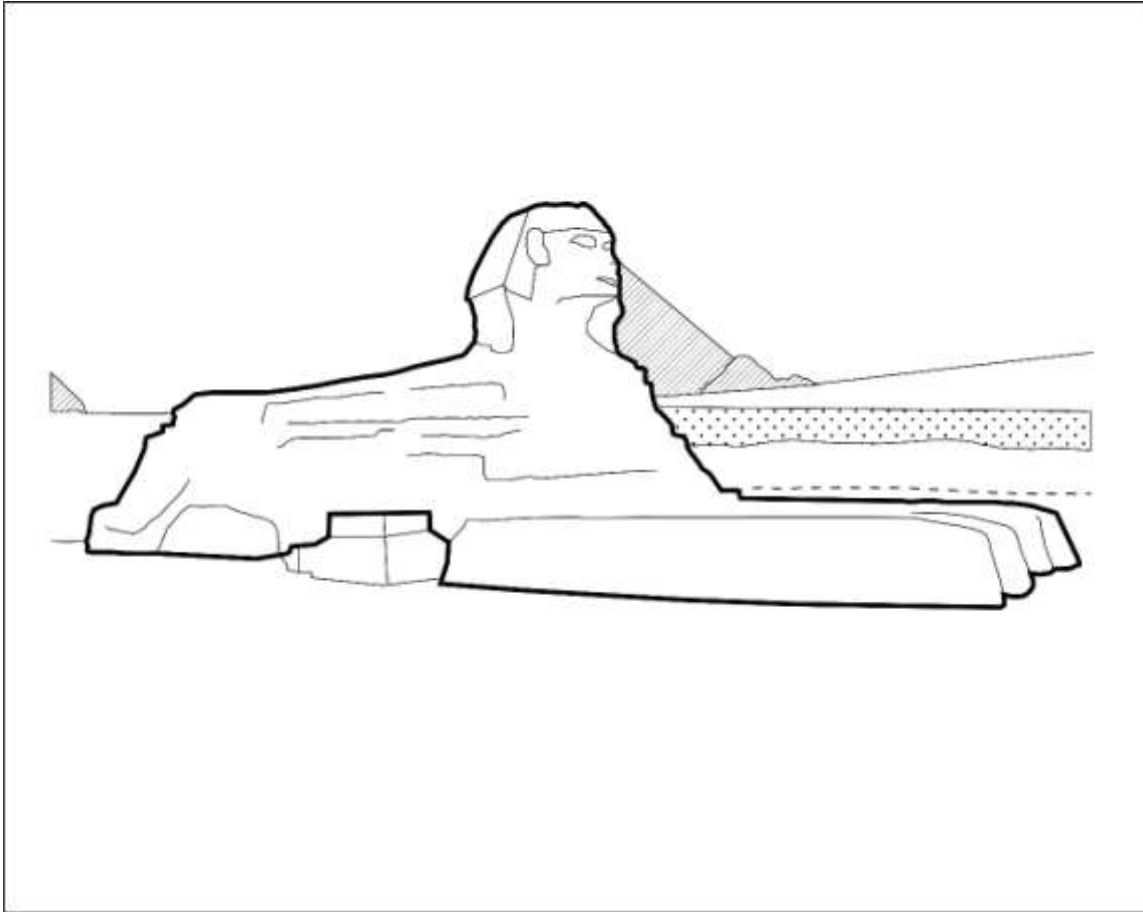
Figure 44 The great sphynx - Tactile image
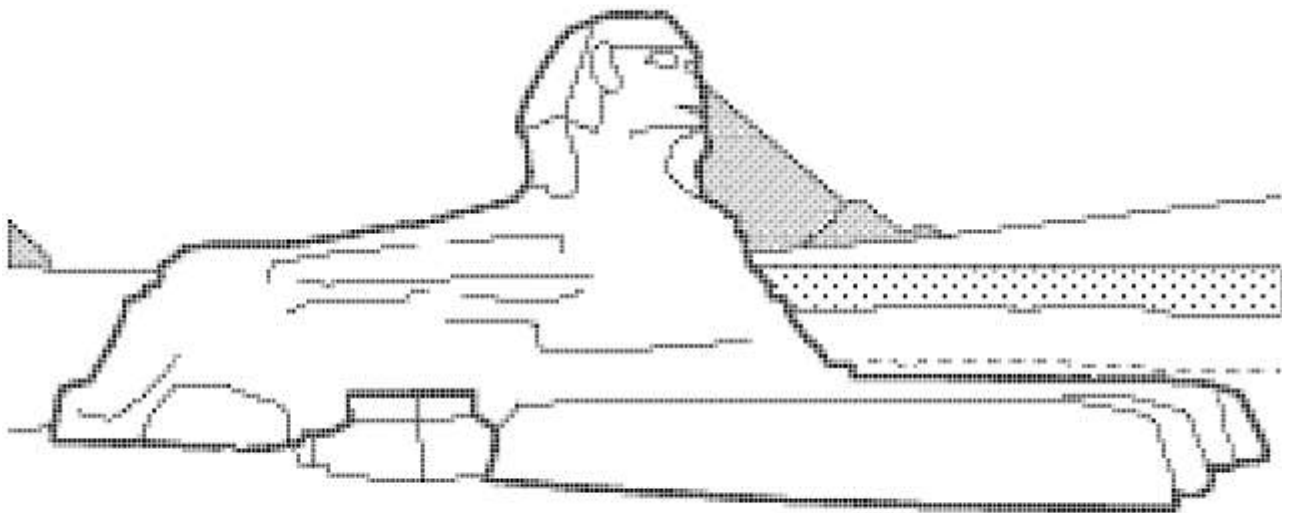
Figure 45 The great sphynx - Tactile image printed with tiger embosser

Inductor

The image of an inductor was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form The vector lines were drawn on top of the original image. The text was converted in English and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
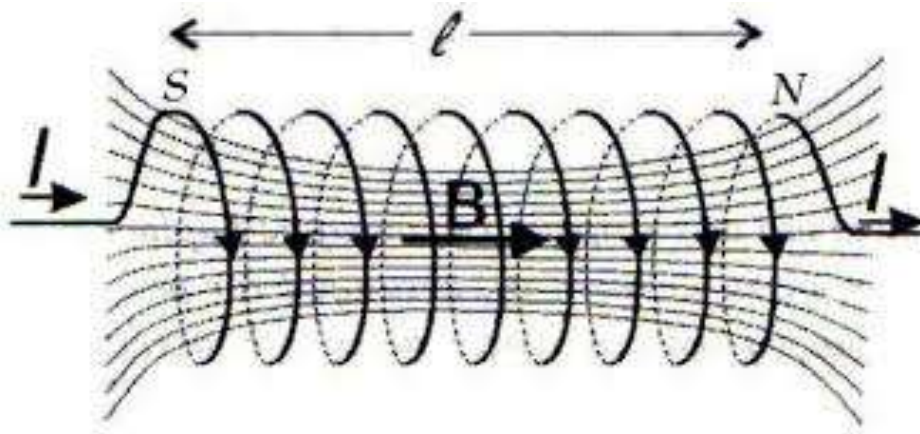
Figure 46 Inductor- The original image
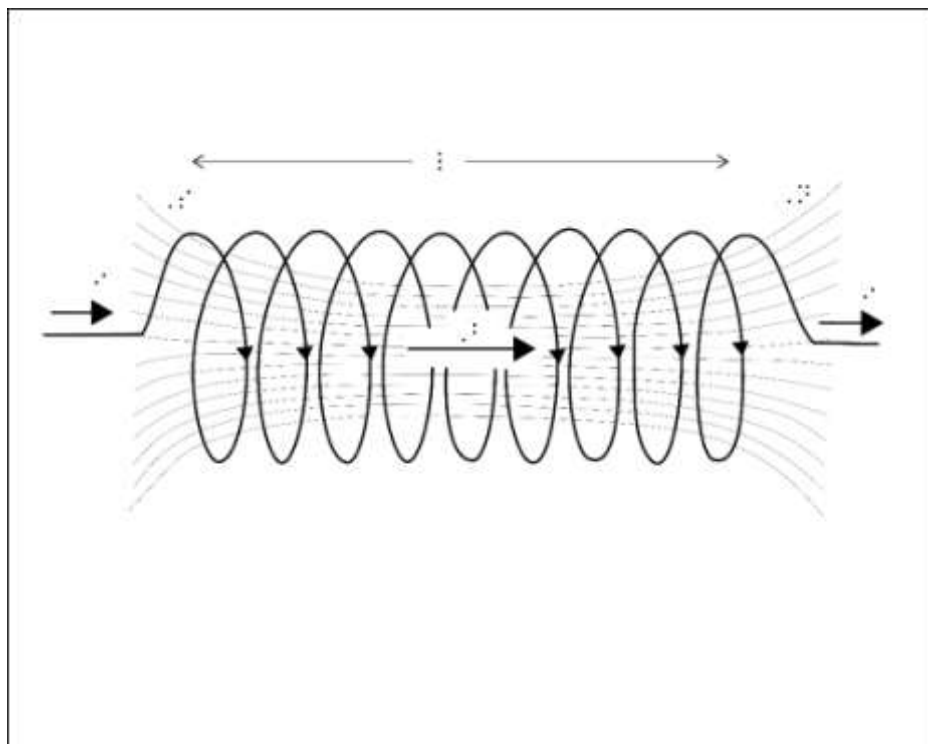
Figure 47 Inductor - Tactile image
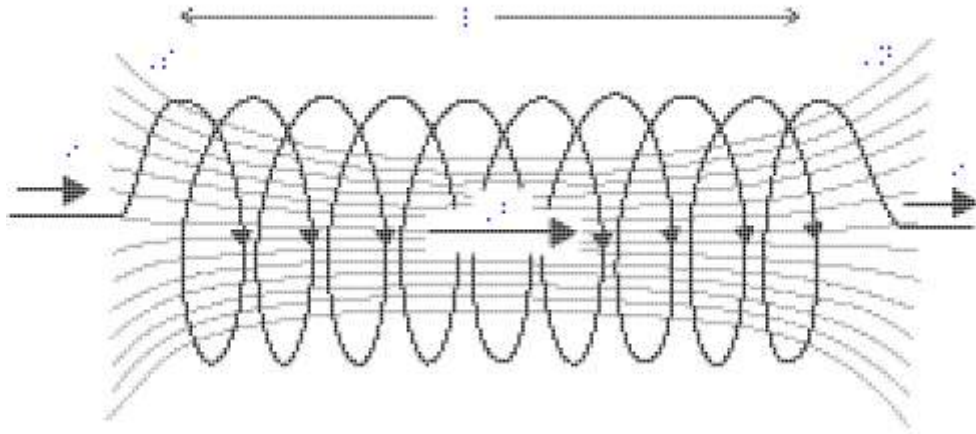
Figure 48 Inductor - Tactile image printed with Tiger embosser

Mangetic field

The image of a current conductor inside a magnetic field was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The vector lines were drawn on top of the original image. The text was converted in English and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.


*Figure 49 Magnetic field- The original image*

Figure 50 Magnetic field - Tactile image
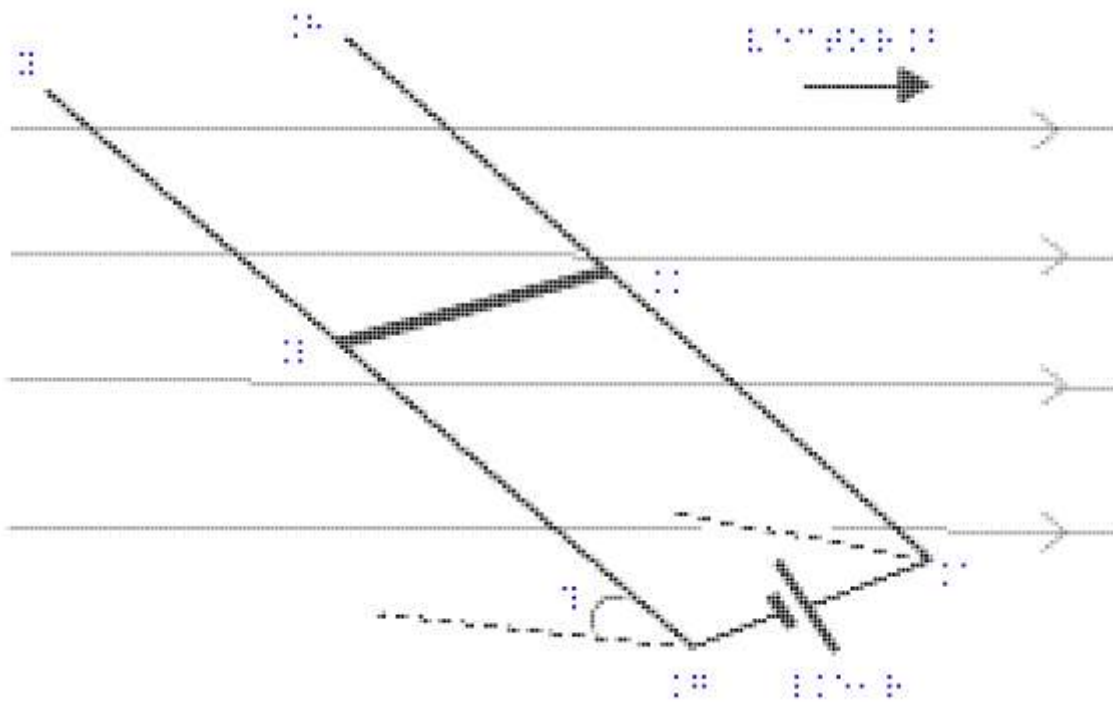
Figure 51 Magnetic field - Tactile image printed with tiger embosser

Plant

The image of the structure of a plant was digitized . On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form.The vector lines were drawn on top of the original image and different texture was placed on different areas. The text was converter in English and Greek braille. Numbers were put instead of the text so that the braille could fit. An extra file was printed in braille as a picture key explaining each number. How each number correspond to the text is shown below

1 top shoot meristem

2 leaf

3 stem

4 knee

5 intercostal space

6 terminal plant eye

7 axillary eye

8 vascular tissue

9 vascular tissue

10 vascular tissue

11 fundamental tissue

12 skin tissue

13 tip

14 plant root

15 top root meristem

16 plant hood

17 root system

18 plant stem

The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.

General structure of higher plants

Figure 52 Plant- The original image
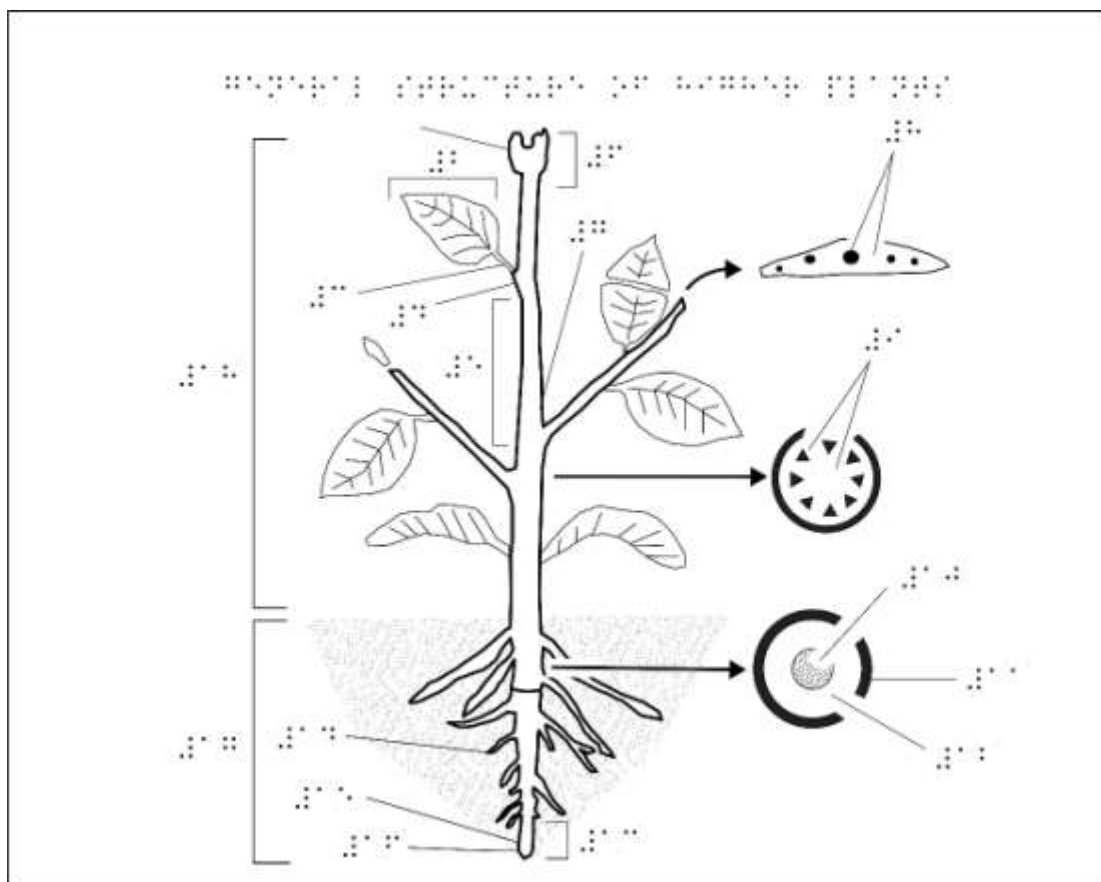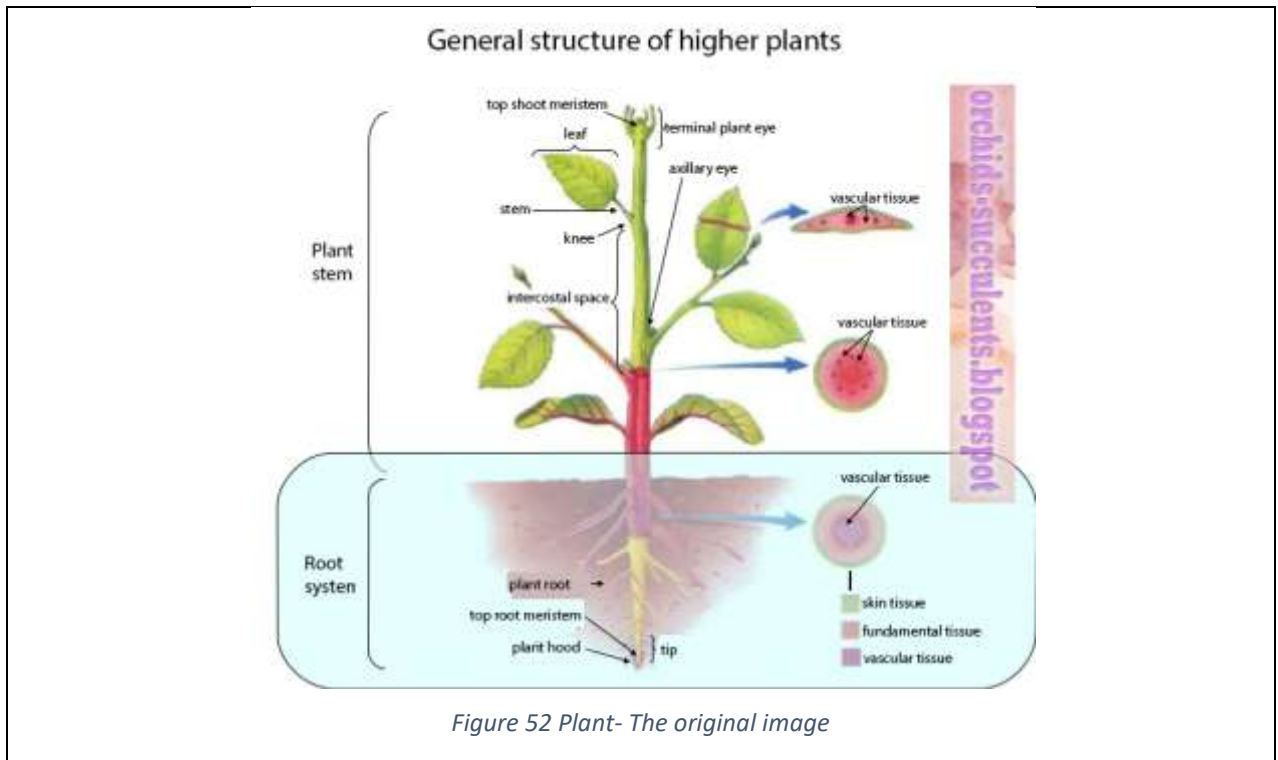
Figure 53 Plant - Tactile image

Figure 54 Plant - Tactile image printed with Tiger embosser

Scatter

The image of a scatter diagram of speed of light in different mediums was digitized . On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The vector lines and shapes were drawn on top of the original image. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
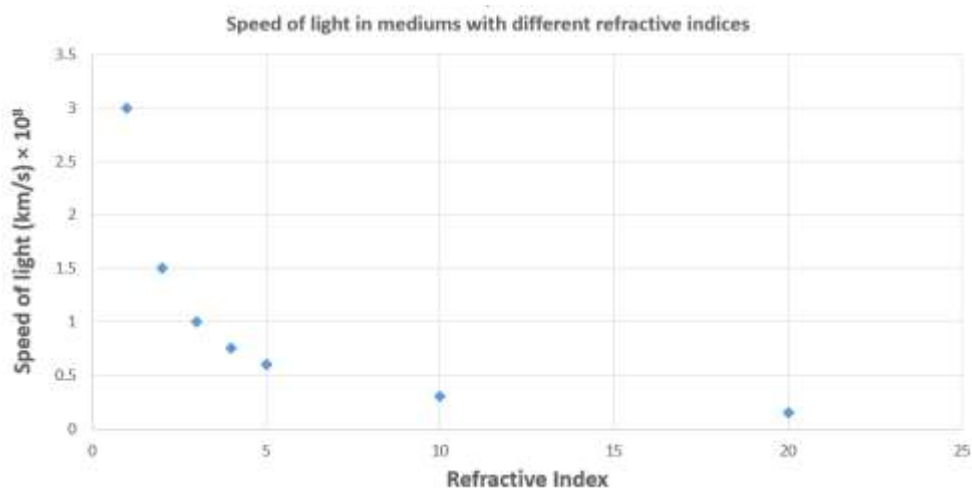

Figure 55 Scatter - The original image
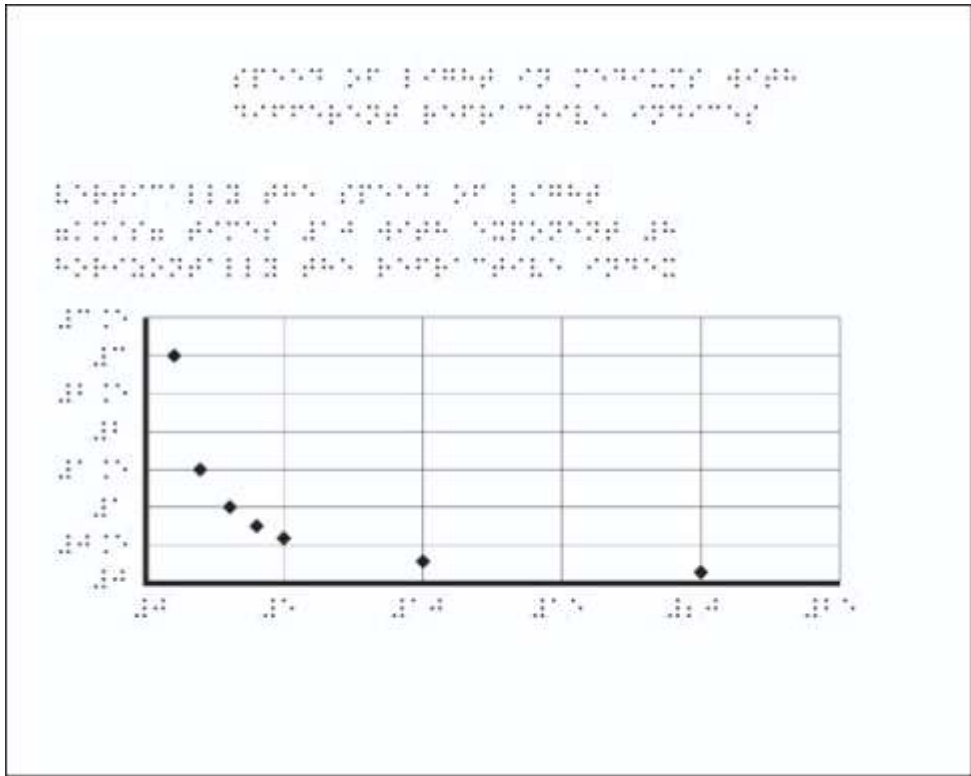
Figure 56 Scatter - Tactile image
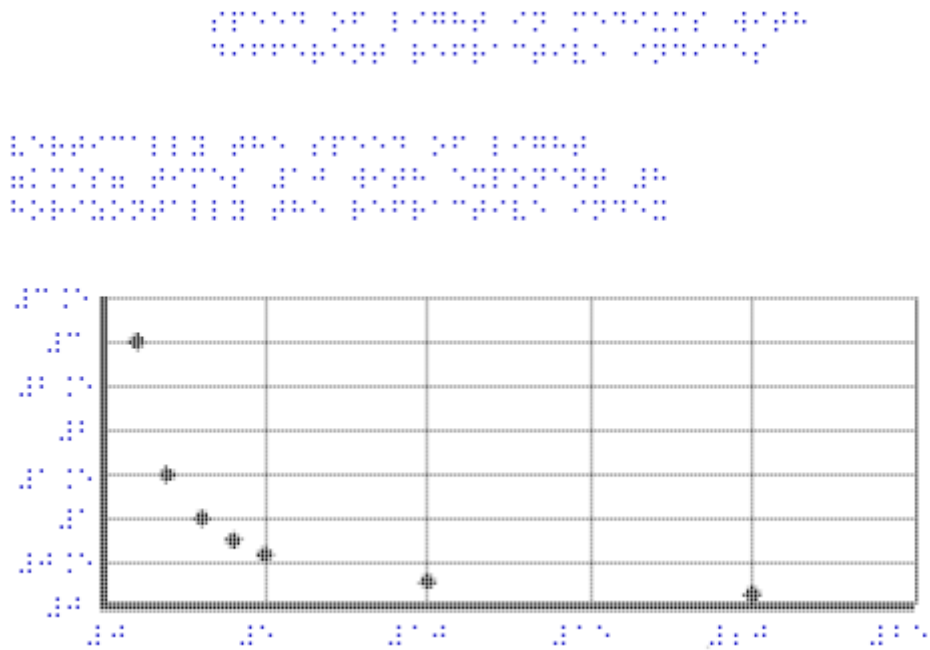
Figure 57 Scatter - Tactile image printed with Tiger embosser

The image of geometric shapes was digitized. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The vector lines were drawn on top of the original image. The shapes had to be rearranged in order to fit correctly in the printing paper. The text was converted in English braille and on top of each shape a number was placed. A separate file was printed as a picture key with the math equations that represent each number. The math equations were also printed in Nemeth code. How each number correspond to the text is shown below.

1 $V = \pi r^2 h$

2 $V = \dfrac{\pi r^2 h}{3}$

3 $V = \dfrac{4}{3}\pi r^3$

4 $V = \dfrac{l * w * h}{3}$

5 $V = \dfrac{b * h * l}{2}$

6 $V = l * w * h$

The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.

Figure 58 Geometric shapes- The original image
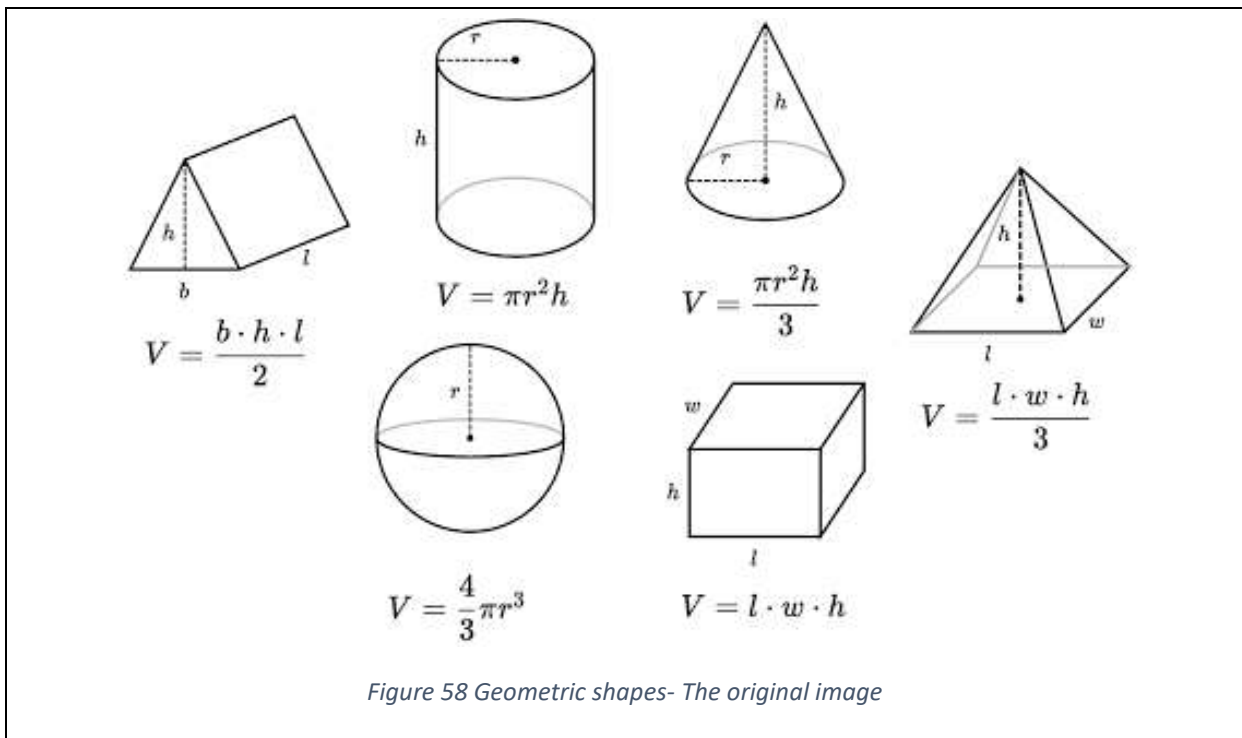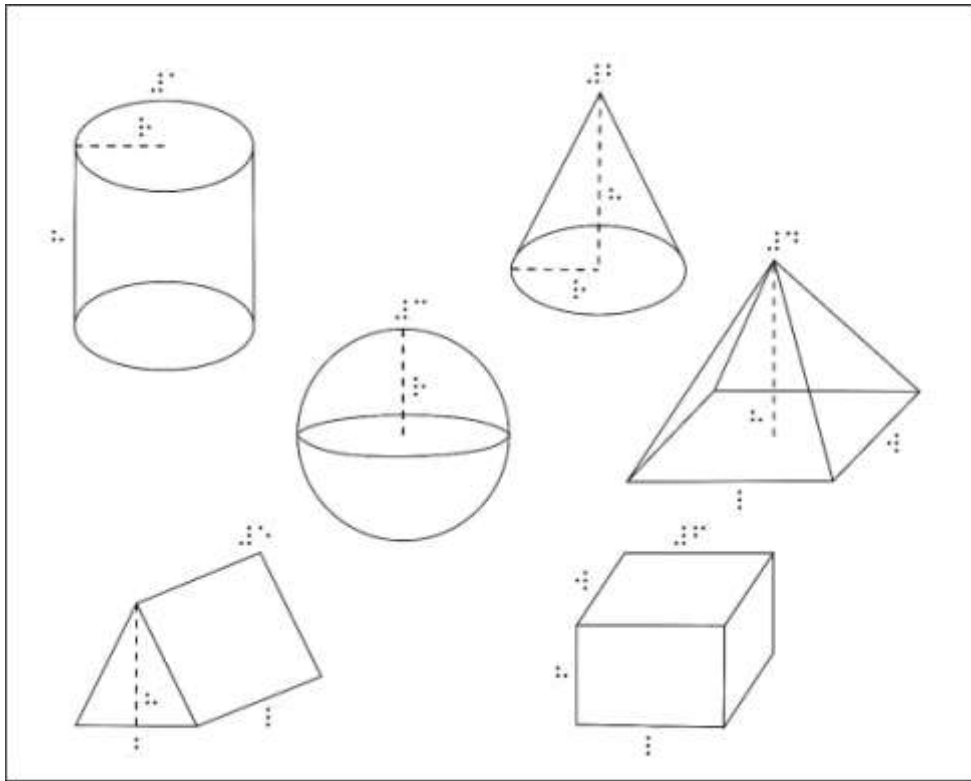
Figure 59 Geometric shapes - Tactile image
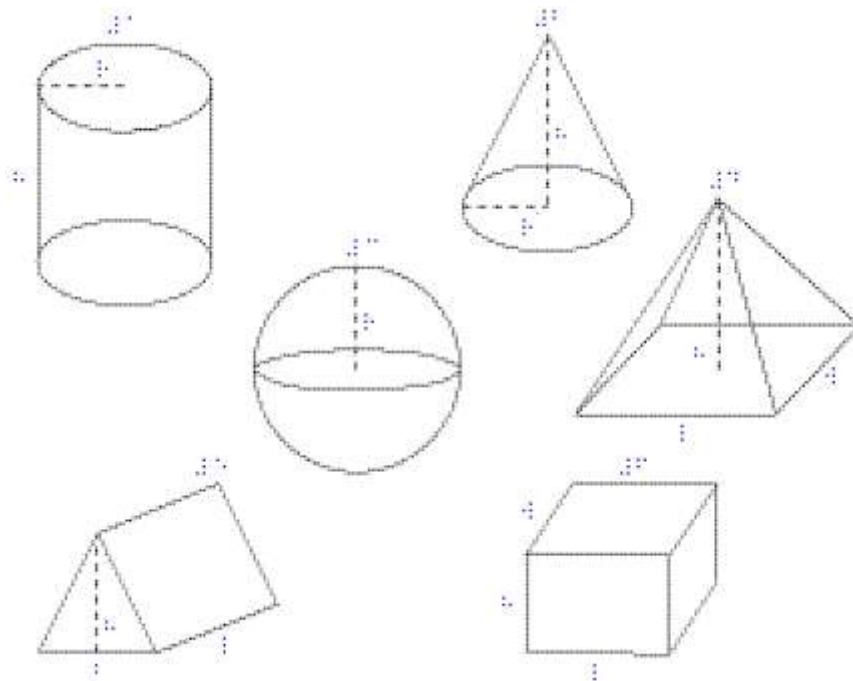
*Figure 60 Geometric shapes - Tactile image printed with Tiger embosser*

The next image that was digitized was the bar chart with the trend in number of children age 6 – 21 diagnosed with autism served under IDEA by age. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The bars where digitized as vector objects. The text was converted in English and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
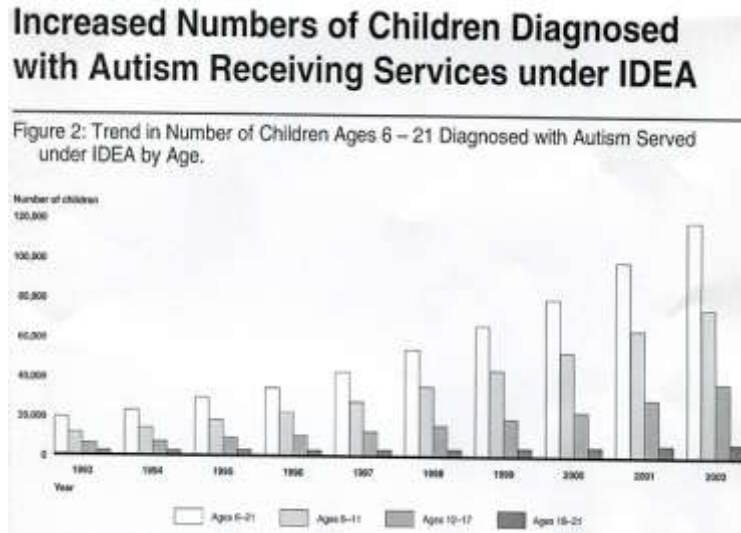
Figure 61 Bar chart 2 - The original image
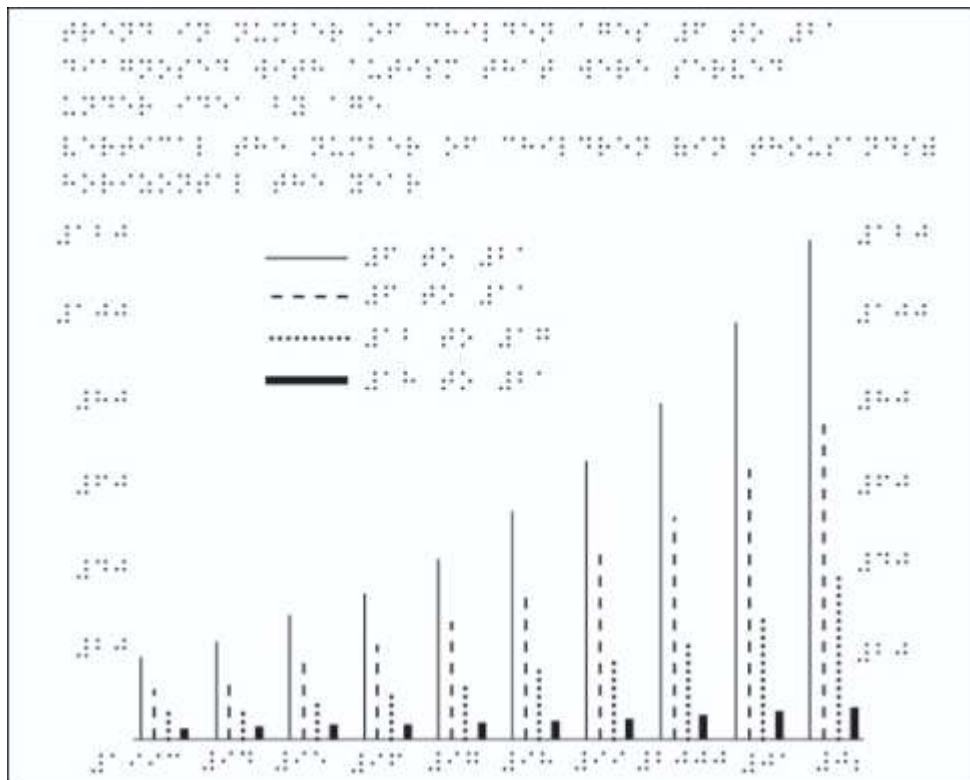
Figure 62 Bar chart 2 - Tactile image
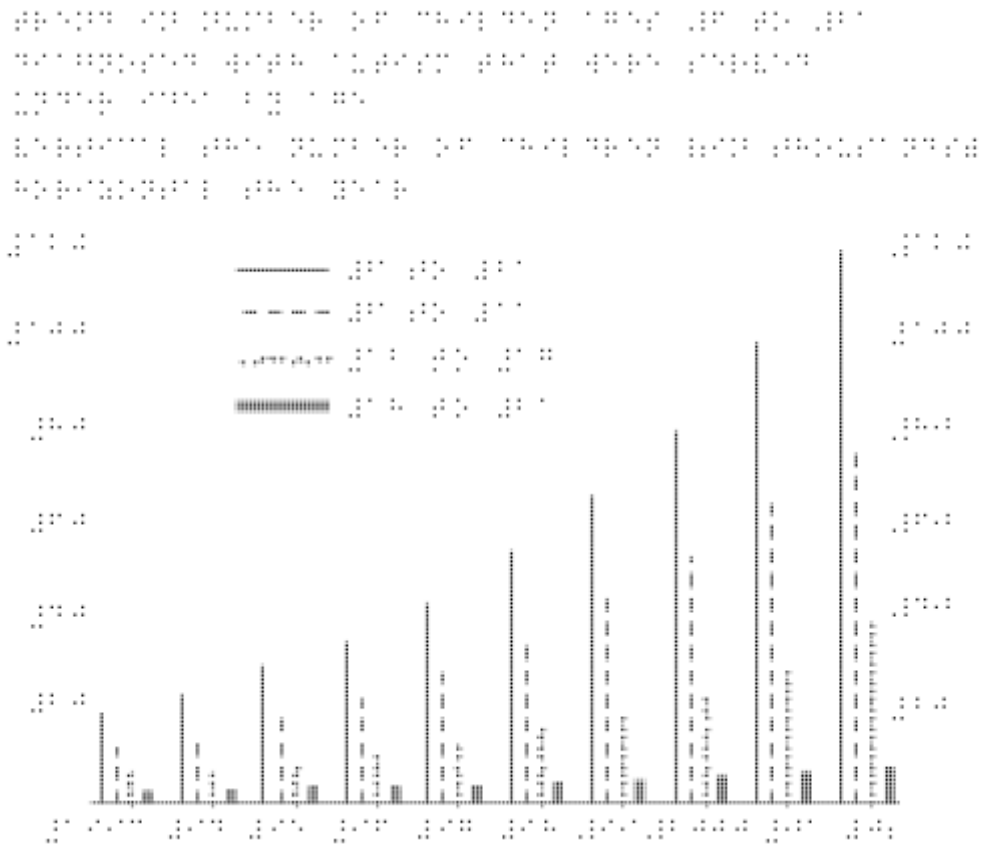
Figure 63 Bar chart 2 - Tactile image printed with Tiger embosser

Line chart

The next image that was digitized was the line chart with the trend in number of children age 6 – 21 with certain low incidence disabilities. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The lines where digitized as vector objects. The text was converted in English and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
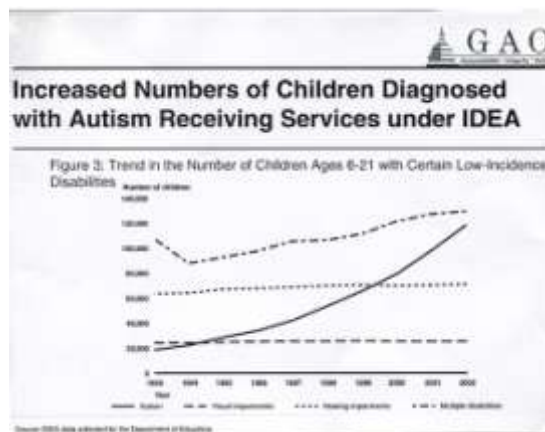
Figure 64 Line chart - The original image
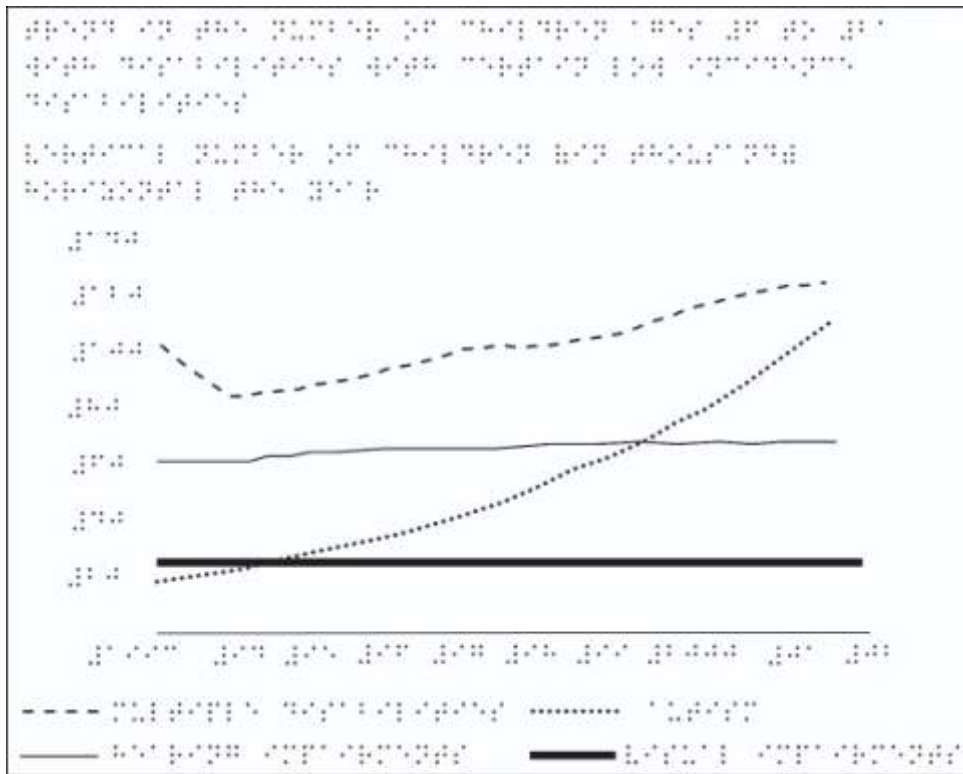
Figure 65 Line chart - Tactile image
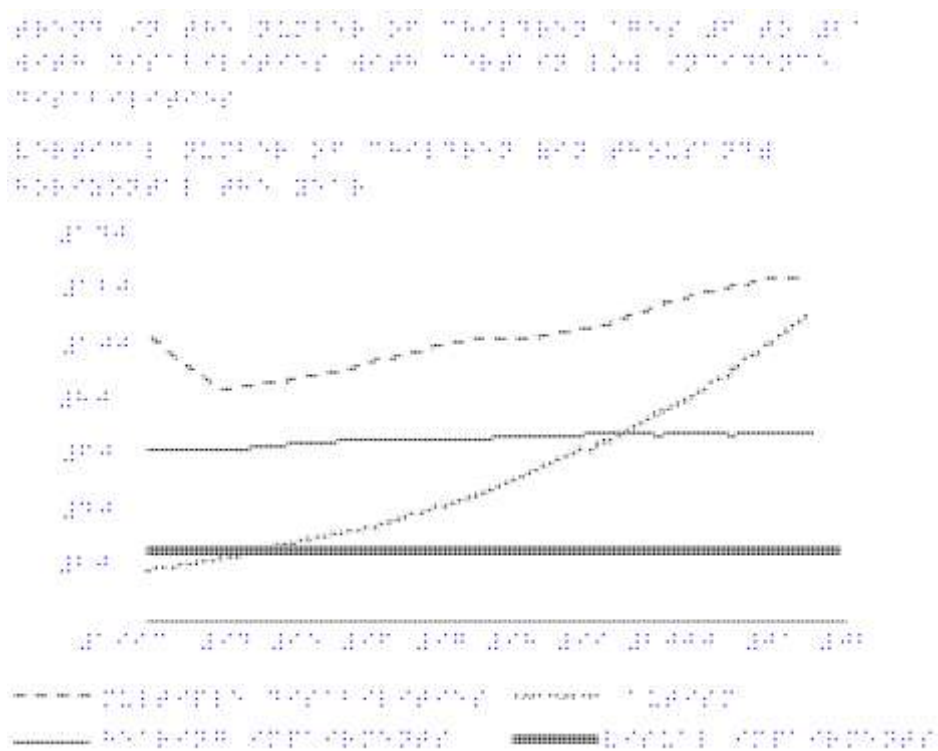
Figure 66 Line chart - Tactile image printed with Tiger embosser

Pie chart

The next image that was digitized was pie chart with percentage of different learning disabilities. On screen digitizing was performed along with some generalization. The image then was processed in order to acquire the correct tactile form. The different parts of the pie where digitized as vector objects. The text was converted in English and Greek braille. The different tactile images are shown below. The one produced by PIAF tactile image maker and the one embossed by tiger embosser.
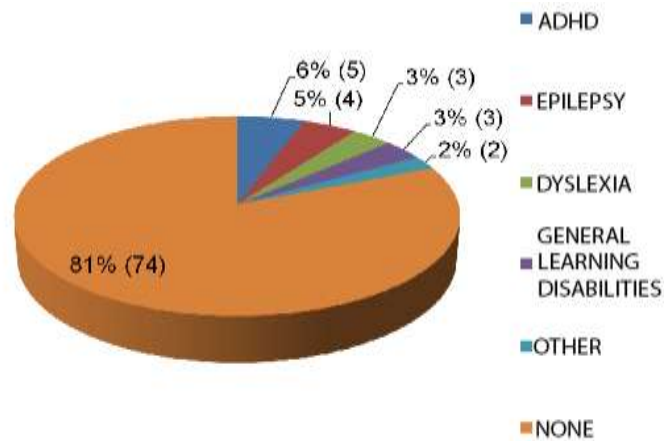
Figure 67 Pie chart - The original image
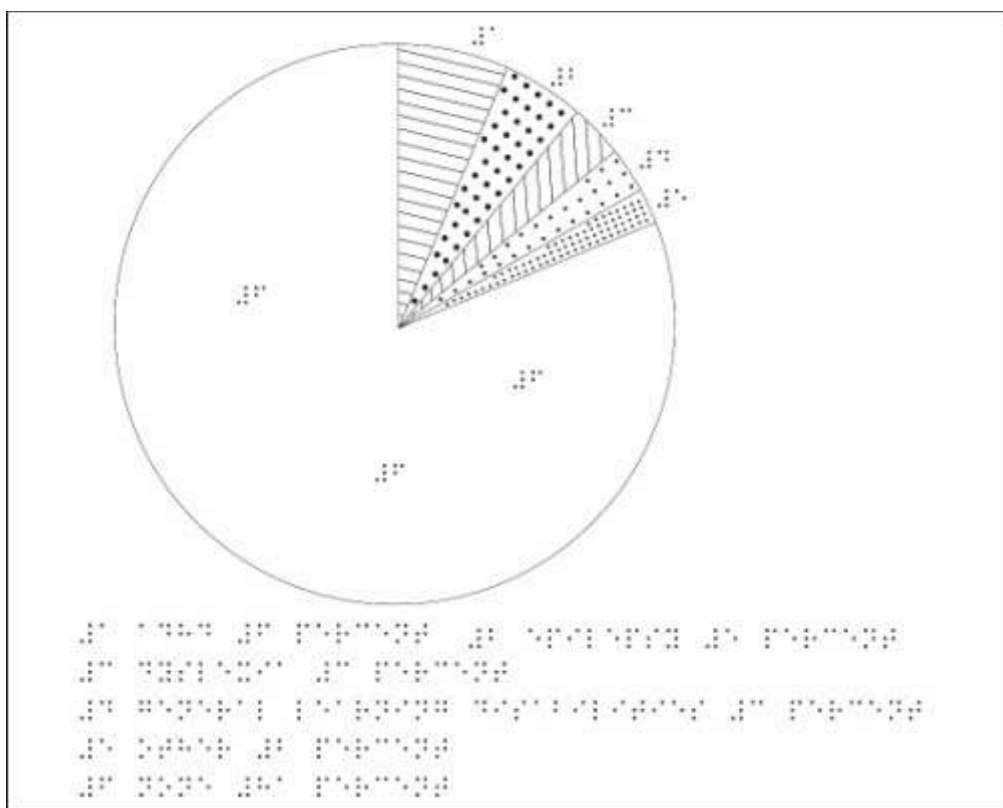
Figure 68 Pie chart - Tactile image

Figure 69 Pie chart - Tactile image printed with Tiger embosser
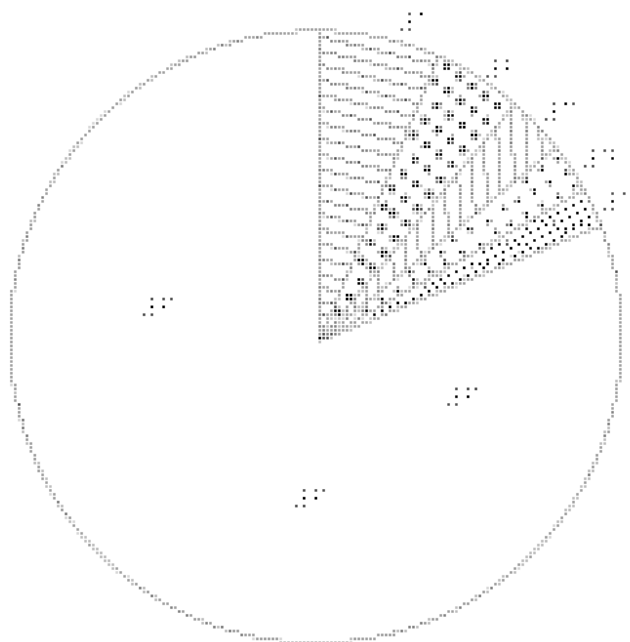
The automatic export of the original images with tiger embosser seemed problematic in most images and thus are not present in this report. The tactile images that were printed were not distinguishable. This, of course, is also expected to be proven in the pilot test with the end users. Many images like the atom, the human brain, the map of me byzantine empire, the discobolus of Myron and the eye anatomy where processed with Viewplus Designer program and new texture was applied on different areas.

2.4.9. Audio-Tactile content

Objective

The main objective was the creation of audio-tactile content as multisensory educational tools and as a way of understanding complex educational information by individuals with blindness.

Description

In order to create the audio-tactile images, 20 images were chosen from various scientific areas. The first step of the procedure was the creation of tactile images in digital form. The digital tactile images were imported in the ViewPlus IVEO Creator Pro 2 software and after the addition of sound descriptions the.svg audio-tactile files were created. The IVEO Touchpad was then connected to a computer. The printed tactile images were placed on the IVEO touchpad and, by tapping on the

graphic, the embedded audio descriptions were played. This way the individuals with blindness could receive the information by touching and hearing it simultaneously.

The files can be found at "*Audio-tactile Pictures and Charts.zip*".

Development procedure

The first step of creating the tactile images is the on-screen digitizing of the selected images. On screen digitizing is the drawing of vector objects on top of the original image and filling them with different surfaces where necessary. For this purpose, Adobe Illustrator software was used, which is a vector graphics editor and design program. On screen digitizing was performed along with image generalization. The images were then processed in order to acquire the correct tactile form.

The digital tactile images were imported to IVEO Creator Pro 2 software. The tactile images were processed with the tools of the IVEO Creator Pro software and the regions or elements that contained educational information, were associated with an audio description. The audio desrciptions for each element of each audio tactile image were created in both English and Greek language.

Lastly, the IVEO touchpad was connected to a computer. The tactile graphics were placed on the IVEO touchpad and, by tapping on the graphic, the embedded audio descriptions were played.

2.4.10. Visual-audio-tactile content

Objective

The main objective was the creation of audio-visual-tactile content as moltimodal educational tools and as a way of understanding complex educational information by individuals with low vision.

Description

In order to create the visual- audio-tactile image, an image containing a concept map of weather elements was selected. The first step of the procedure was the creation of a tactile image in digital form. The image was processed by setting the appropriate contrast, font size, line and character distance. The digital tactile image was imported in the program IVEO Creator Pro 2 software and after the addition of sound descriptions an .svg audio-visulal-tactile file was created. The IVEO touchpad was then connected to a computer. The printed tactile image was placed on the IVEO touchpad and, by tapping on the graphic, the embedded audio descriptions were played. This way the individuals with low vision can receive the information by watching, touching and hearing it simultaneously.

The files can be found at "*Visual-audio-tactile Pictures and Charts.zip*".

Development procedure

The first step of creating the tactile image was the on-screen digitizing. On screen digitizing is the drawing of vector objects on top of the original image and filling them with different surfaces where necessary. For this purpose the Adobe Illustrator software was used, which is a vector graphics editor and design program. On screen digitizing was performed along with some image generalization. The image then was processed in order to acquire the correct tactile form.

The digital tactile image was imported to IVEO Creator Pro 2 software. The tactile image was processed with the tools of the software and the regions or elements that contained educational information, were associated with an audio description. The audio descriptions for each element were created in both English and Greek Language.

Lastly, the IVEO touchpad was connected to a computer. The tactile graphics were placed on the IVEO touchpad and, by tapping on the graphic, the embedded audio descriptions were played.

Additionally, the educational information can be heard by clicking with the computer mouse on the respective created element on top of the image.

2.4.11. Developing accessible video content

This section presents the process of developing or adopting educational material in the form of digital video, with focus on accessibility and inclusion features that will meet the needs of individuals with disabilities. Accessibility features of this type of educational material are especially applicable to individuals with visual or hearing impairments.

Due to the technological advancements of the last decade concerning internet broadband connections, like never before, digital video content (e.g. YouTube) is dominant in communication / news / social media but also in education (e.g. Massive Open Online Courses (MOOCS), distance learning).

The challenge of making this content accessible to everyone is in the scope of national or international organizations and initiatives, like the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C, 2020), or the Described and Captioned Media Program which is funded by the U.S. Department of Education and administered by the National Association of the Deaf (DCMP, 2020).

WAI (2019), suggests the following ways of making accessible media especially concerning individuals with visual or hearing impairments:

- **Audio Description of Visual Information** - Description provides content to individuals who are blind and others who cannot see the video adequately. It describes visual information needed to understand the content.
- **Captions/Subtitles** - Captions (also called "subtitles") provide content to individuals who are Deaf and hard-of-hearing. Captions are a text version of the speech and non-speech audio information needed to understand the content. They are synchronized with the audio and usually shown in a media player when users turn them on.
- **Transcripts** - Basic transcripts are a text version of the speech and non-speech audio information needed to understand the content. Descriptive transcripts also include text description of the visual information needed to understand the content. Descriptive transcripts are required to provide video content to individuals who are both Deaf and blind.
- **Sign Languages** - Sign languages use hand and arm movements, facial expressions, and body positions to convey meaning. For many individuals who are Deaf, sign language is their native language, and some do not understand written language well. (Sign language is not required by most policies.)

Definitions

The terms "captions" and "subtitles" are sometimes used interchangeably for the same thing in different regions of the world. In this document we use the following rule of thumb (WAI, 2020):

- **Captions** for the same language as the spoken audio.
- **Subtitles** for spoken audio translated into another language.

Captions are needed for accessibility, whereas subtitles in other languages are not directly an accessibility accommodation.

Moreover, according to Wikipedia (2020), the following very similar definitions are used in the HTML5 standard:

- **Captions:** "transcription or translation of the dialogue, sound effects, relevant musical cues, and other relevant audio information when sound is unavailable or not clearly audible" (for example, when audio is muted or the viewer is deaf or hard of hearing)
- **Subtitles:** "transcription or translation of the dialogue when sound is available but not understood" by the viewer (for example, dialogue in a foreign language)

Providing captions to video content can be helpful for conveying the displayed information to deaf or hard of hearing individuals, but also to individuals that process written information better than audio (WAI, 2020).

There are two ways of delivering captions:

- "**open captions**", that are always displayed on the screen and cannot be turned off
- "**closed captions**", that are most commonly used and users can decide whether to be displayed or not.

In either case, the process of creating captions has the same starting point – transcribing the content of the video.

Good Practices

The Federal Communications Commission (FCC, 2020), has set some standards for providing accessibility concerning television programs, in terms of closed captioning:

FCC (2020) rules for TV closed captioning ensure that viewers who are deaf and hard of hearing have full access to programming, address captioning quality and provide guidance to video programming distributors and programmers. The rules apply to all television programming with captions, requiring that captions be:

- **Accurate**: Captions must match the spoken words in the dialogue and convey background noises and other sounds to the fullest extent possible.
- **Synchronous**: Captions must coincide with their corresponding spoken words and sounds to the greatest extent possible and must be displayed on the screen at a speed that can be read by viewers.
- **Complete**: Captions must run from the beginning to the end of the program to the fullest extent possible.
- **Properly placed**: Captions should not block other important visual content on the screen, overlap one another or run off the edge of the video screen.

Despite the fact that these rules refer to TV programs, should be considered as applicable to any kind of captioning, including digital videos locally stored or a YouTube video.

Objective

Captioning a video can provide accessibility options to individuals who are deaf, hard of hearing or cannot hear the audio for any other reason (e.g. noisy surroundings).

Closed captioning gives the option to the viewer of the video, to switch on / off the captions, according to his/her needs. This technique is also useful for creating multilingual material, since more than one caption files can be paired with the same video file.

Video captioning can be applicable to local video files, using a compatible media player (e.g. VLC) or to video streaming services (e.g. YouTube, Vimeo).

On the downside, there are some media players that may not support closed captioning and captioning of a streaming video is usually an option provided by the author/owner of the media. Streaming services (e.g. YouTube) may support automatic captioning, but this is at the moment quite problematic, since there are limitations to the supported languages or the accuracy of the transcription.

Description

In a "closed captioned" video, captions can be displayed or not, providing this choice to the viewer. This might be a useful option, especially for media addressed to a mixed population comprising individuals with or without hearing disabilities.

Captions are a text version of the verbal or non-verbal audio information needed to understand the content. They are displayed within the media player (if turned on) and are synchronized with the audio/video information.

Figure 70 Screenshot from YouTube video: "How a cyborg artist 'hears' colours - le mag".

In this section, we report on the process of creating captions for the video "How a cyborg artist 'hears' colours - le mag" from "Euronews" YouTube Channel. The original video is provided without captions.

- • English version: https://youtu.be/bg68jv-rkY0
- • Greek version: https://youtu.be/ZEwmGffKIcs
- • French version: https://youtu.be/XbCdxHOORC8

This video was selected because of the duration, which was convenient in a way that we were able to apply and display the various captioning techniques, like captioning verbal and non-verbal information, while on the other hand not too lengthy.

Additionally, the content of the video (about a man with a visual disability) is considered to be of educational interest considering the targeted population.

Another reason for selecting this video, was that it is already provided in an number of different languages and can this way be used for providing similar conditions during the research conducted from the multilingual consortium of this project.

Development procedure

The first step of the captioning procedure is the transcription of the audio information. For this purpose, a number of applications / software could be used, either desktop or web based.

In this case, for the creation of the closed captions, we have used the CADET (Caption and Description Editing Tool) software (WGBH, 2020), developed by the National Center for Accessible Media at WGBH (NCAM).

We have used CADET because it is a free, easy to use caption-authoring software that enables anyone to produce high-quality caption files that are compatible with any media player that supports the display of captions. CADET can also be used to generate audio-description scripts. Furthermore, CADET itself is accessible to use, and NCAM has created a series of free captioned tutorials on YouTube (e.g. https://youtu.be/B7T4MgAUwos)
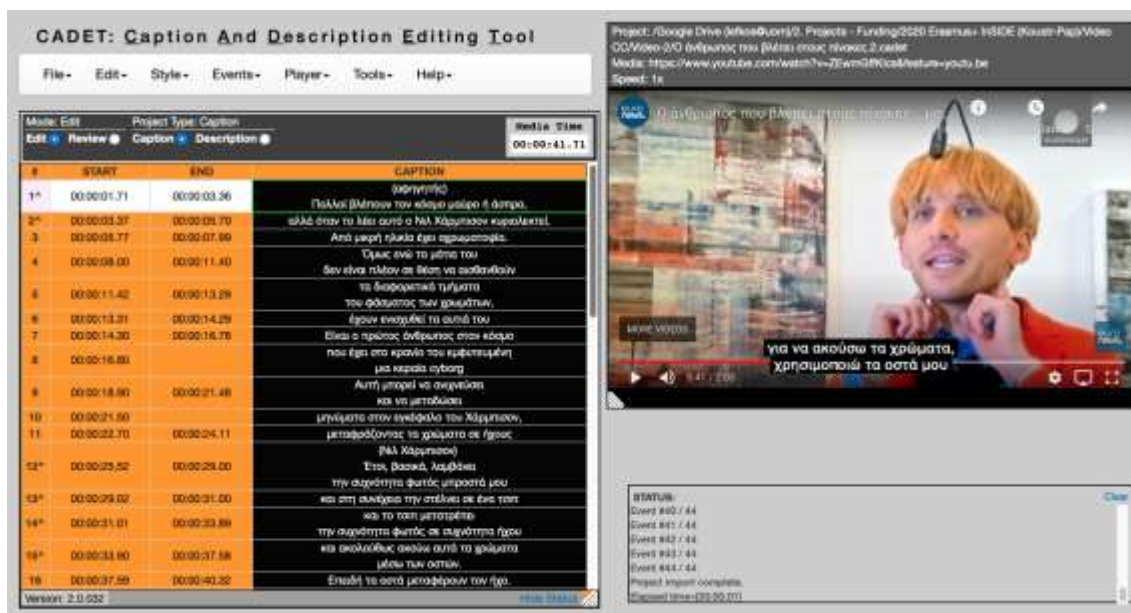
Figure 71 Creating captions with CADET - a typical layout of the workspace. The caption file (left) can be saved as a time marked text file.

Following very simple guidelines from the CADET documentation file (http://ncamftp.wgbh.org/cadet/help/captioning.html), it is very easy to create a caption file.

1. Start a new captioning project
2. Import a local or remote clip (e.g. from YouTube or Vimeo)
3. Start creating captions
4. Review and properly adjust timing for your captions
5. Save the project by giving a meaningful name (e.g. "The man who can hear the colors")
6. Export the captions text file, using one of the provided file types (e.g. *.srt, which is the most commonly used)

Materials

This material (in English), is related to the deliverable D.2.1 of the project and comprises a number of files, hence for convenience it is the compressed file titled *"a - How a cyborg artist 'hears' colours.closed_captions_en.zip"*.

The files include the original video, the caption files (.srt & .vtt formats) and a link to a YouTube video with closed captions added, to demonstrate this technique.

The respected files were additionally created in Greek, in order to be useful to the Greek speaking audience and also be **used for the pilot tests (D.2.2). The corresponding compressed file for Greek speaking audience is titled** *"a - How a cyborg artist 'hears' colours.closed_captions_gr.zip"*.

B - Open Captioned video

Objective

Captioning a video can provide accessibility options to individuals who are deaf, hard of hearing or cannot hear the audio for any other reason (e.g. noisy surroundings).

Open captioning refers to the situation of captions that are embedded in the picture and are always visible to the viewer of the video (cannot be switched on / off).

This technique limits the options of the user, but on the other hand it holds the great advantage of the captions being always available and visible, independently of the viewer being used.

Another disadvantage of open captioning is the fact that in order to provide multilingual material, a complete new video with captions has to be created for every different language (in the case of subtitling).

Description

In an "opened captioned" video, captions are always visible to the viewer.

Captions are a text version of the verbal or non-verbal audio information needed to understand the content. They are displayed within the picture and are synchronized with the audio/video information.

Figure 72 Video with open captions. Open captions can be easily relocated so that they do not overlap with the video content

In this section, we report on the process of creating captions for the video "How a cyborg artist 'hears' colours - le mag" from "Euronews" YouTube Channel. The original video is provided without captions. For this Projects purpose of open captioning, the video was first stored locally from YouTube, using an online downloader.

This video was selected because of the duration, which was convenient in a way that we were able to apply and display the various captioning techniques, like captioning verbal and non-verbal information, while on the other hand not too lengthy.

Additionally, the content of the video (about a man with a visual disability) is considered to be of educational interest considering the targeted population.

Another reason for selecting this video, was that it is already provided in an number of different languages and can this way be used for providing similar conditions during the research conducted from the multilingual consortium of this project.

Development procedure

The first step of the captioning procedure is the transcription of the audio information. For this purpose, a number of applications / software could be used, either desktop or web based.

In this case, for the creation of the open captions, we have used the Premiere Pro CC (v. 14.4.0 / Build 38), a blended cloud/desktop application by Adobe, which currently comes as part of the Adobe Creative Cloud suite. Premiere Pro is a leading video editing application, providing speed and precision of workflow.
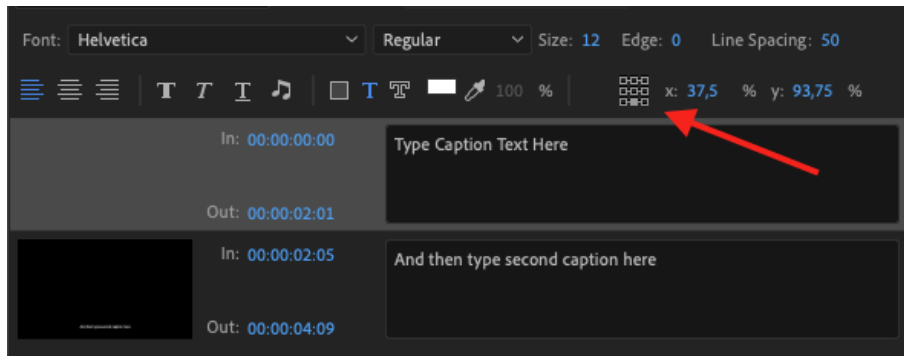
Figure 73 A number of options for the formatting and positioning of open captions, are available in Premiere Pro.

Especially for open captioning, Premiere Pro offers a number of configuration options like changing the font, color, size, style and the position of the captions. One of the most important options is the positioning of the captions. There are 9 preset positions (see red arrow Figure 73), but also x %, y% coordinates, in case a more detailed position is needed.
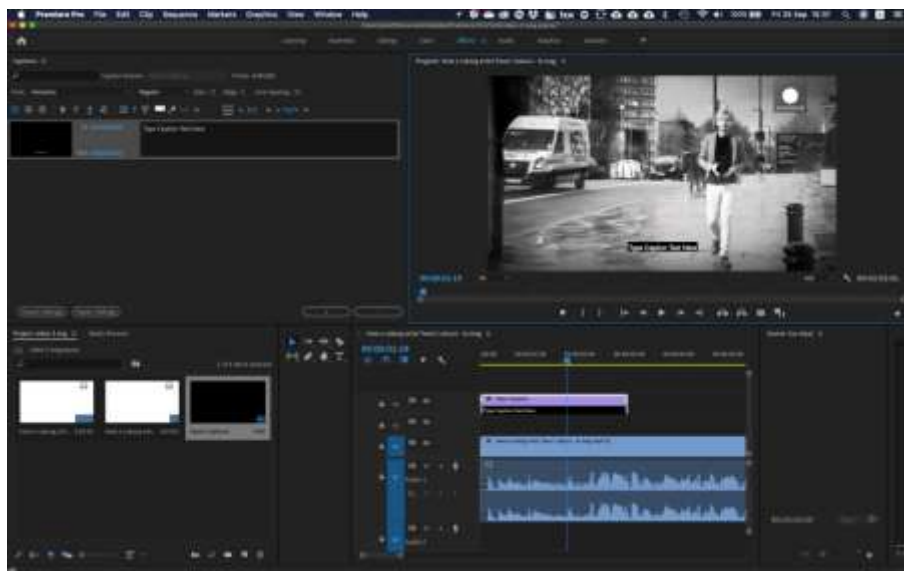
Figure 74 Adobe Premiere Pro CC project workspace while creating open captions (top left panel)

For the creation of the open captions, the procedure is quite straightforward, as described also in the products' online help guide (https://helpx.adobe.com/premiere-pro/how-to/subtitles.html).

1. Create a new project
2. Use File/Import menu, to import the video file from your local disk. This will appear as a new item in the Project panel.
3. Drag the video file to the Sequence panel
4. Use the New Item menu at the bottom of the Project panel and select Captions.
5. Select the "Open Captions" standard at the popup dialog box.
6. Drag/drop the Captions item into the Sequence panel and align it with the video voiceover.

7. Use the Window/Captions menu, to enable the dedicated Captions panel and start typing the captions.
8. Synchronize the captions very easily, by dragging the gray start / end spikes (see red arrows in Figure 75) of each caption frame.
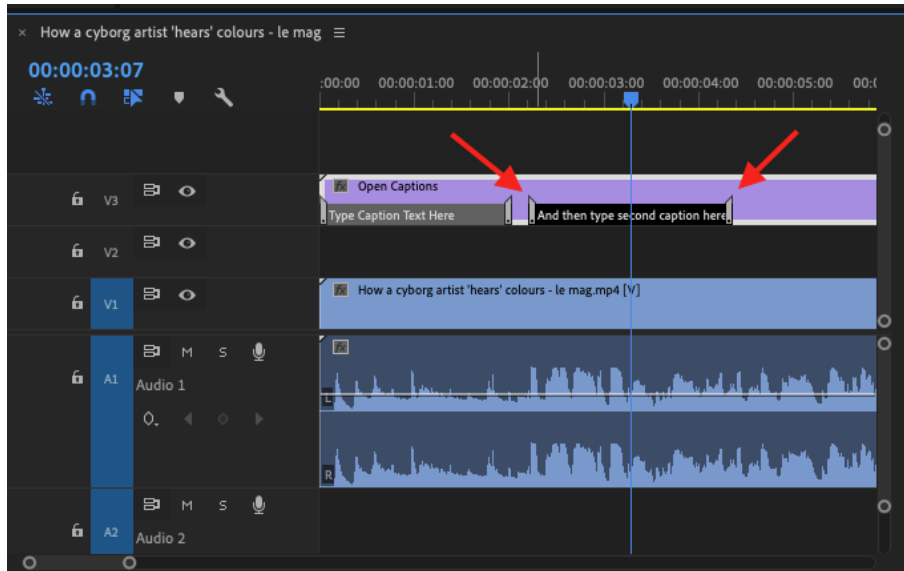
Figure 75 Drag the grey spikes for synchronizing the start / end time position of each caption

The process is practically the same, in case the captions have already been created (like our case) in some other application. Instead of typing from scratch, a caption file could be imported, using the File/Import menu. Premiere Pro, supports the .srt file format for importing captions.
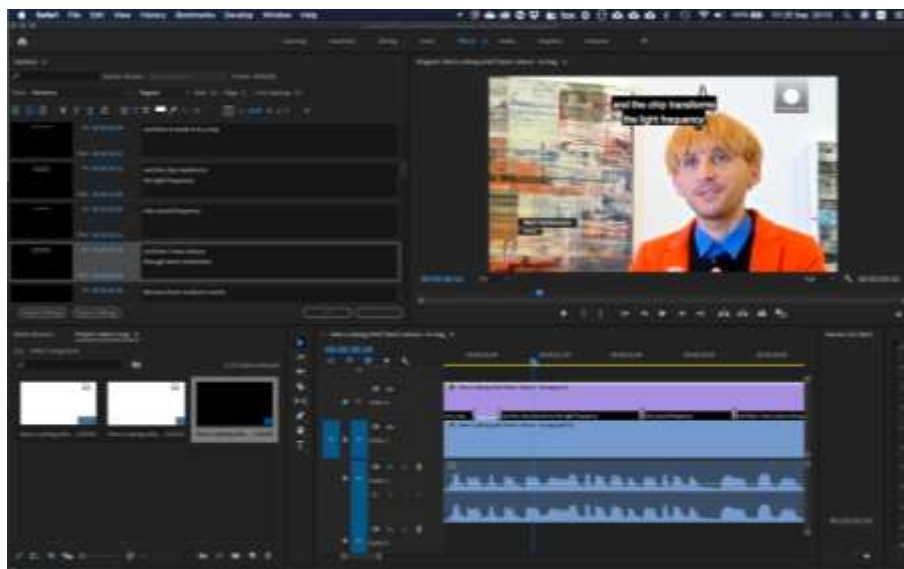
Figure 76 Premiere Pro project workspace while syncing open captions (top left panel. Captions should be positioned in such a way that no other on screen information is covered.

Final step of the procedure is the creation of the output video file, with the open captions embedded in the picture. Use the File / Export / Media menu, and at the popup dialogue window, make sure to select the submenu "captions" and then "Burn captions into Video" (red arrows in Figure 77). This action will render the video file including the captions in the picture.
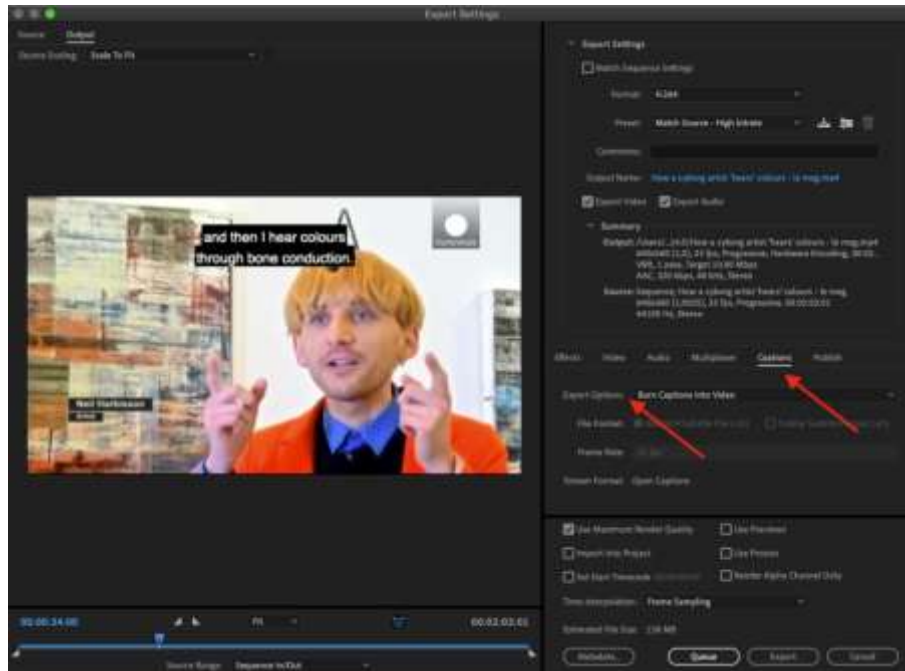
Figure 77 Exporting the video file and making sure to "Burn the captions into Video"

Materials

This material (in English), is related to the deliverable D.2.1 of the project and is the video file titled

"b - How a cyborg artist 'hears' colours.open_captions_en.mp4".

The respected file was additionally created in Greek, in order to be useful to the Greek speaking audience and also be used for the pilot tests (D.2.2). The corresponding video file for Greek speaking audience is *"b - How a cyborg artist 'hears' colours.open_captions_gr.mpg"*.

C - Video with sign language translation

Objective

Creating a video with sign language translation, can provide access to a video content, for individuals that are Deaf or Hard of hearing. This kind of translation is mostly used for live / real-time video broadcasting. But, since for many individuals who are Deaf, sign language is their native language and some do not understand written language well, it can also be proven useful in cases like these.

Although signing is used primarily by the deaf and hard of hearing, it is also used by hearing individuals, such as those unable to physically speak, those who have trouble with spoken language due to a disability or condition (augmentative and alternative communication), or those with deaf family members, such as children of deaf adults (Wikipedia, 2020).

Description

A video with sing language translation, is practically the creation of a video file, that has a video frame, displaying the sign language translator, embedded into the original video. The sign language translation has to be synchronized with the audio information of the original video. It highly resembles the Picture-In-Picture (PIP) display, used sometimes on TV.

The positioning of the superimposed video frame has to be thoroughly considered, so that it does not cover important information presented in the original file.

In our case, the translator's frame was embedded into the top right corner of the screen, because the information of the original file, is mainly positioned at the center-left side.

A different approach would be to position the translator's frame outside of the original video frame. This is a very common solution, but as result the original video frame has to be reduced and this way details might be lost. On the other hand, no part of the original video file is covered. Deciding between these two approaches, depends highly on the specific information presented in the original video. For example it would be more suitable to use the first technique for translating the news or an interview (like in our case), but the second one for an action movie.

Development procedure

For the purpose of embedding a video frame, a number of applications / software could be used, either desktop or web based. In this case, for the creation of the sign language translated video, we have used the Premiere Pro (v. 14.4.0 / Build 38), a blended cloud/desktop application by Adobe, which currently comes as part of the Adobe Creative Cloud suite. Premiere Pro is a leading video editing application, providing speed and precision of workflow.
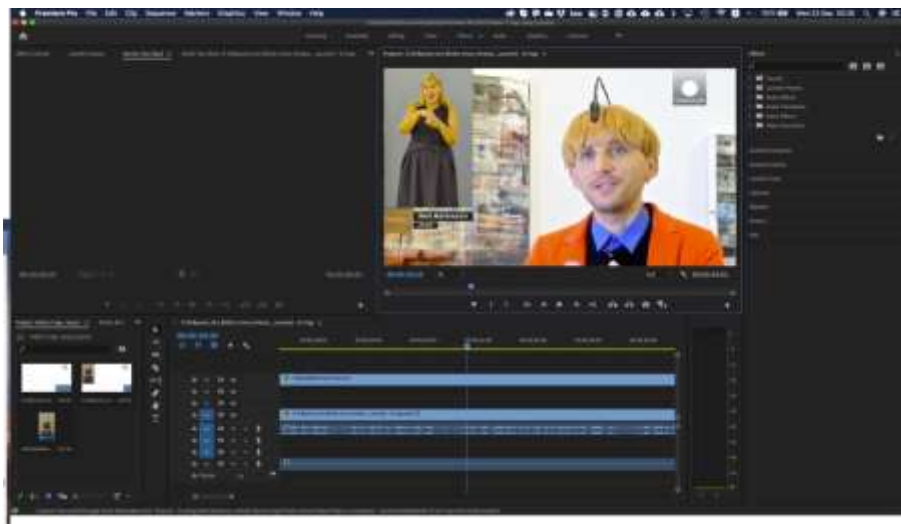
Figure 78 Adobe Premiere Pro CC project workspace for superimposing a video frame into the original video

Creating this sign language translated video in Premiere Pro, is a very easy process, as described below:

1. Create a new project
2. Import the original video file, using the File / Import menu.
3. Drag the file into the Sequence panel.
4. Import the sign language translator video file, using the same menu items as above.
5. Drag the second file into the Sequence panel. Make sure it is placed above the first one (so that it is also displayed on top).
6. Resize the second video file and place the frame into the desired position.
7. Synchronize the sign language video file, according to the audio information of the first file (by dragging the starting point).
8. Export the new video file using the File / Export / Media menu.

Figure 79 The video file with a synchronized sign language translator displayed in a frame like PIP

Materials

This material is the video file titled *"c - How a cyborg artist 'hears' colours.sign_lang_gr.mp4"*.

The respected file was created in Greek, in order to be useful to the Greek speaking audience and also be used for the pilot tests (D2.2).

There is not a corresponding English file available.

D - Video descriptive transcript

Objective

A descriptive transcript, can provide accessibility options to a video file, for individuals with visual impairments. Descriptive transcripts also include text description of the visual information needed to understand the content (WAI, 2019b). Descriptive transcripts are required to provide video content to individuals who are both Deaf and blind. They can also be used by individuals who process text information better than audio and visual/pictorial information.

The descriptive transcript can be used as an input for a human narrator an audio-description track or a text-to-speech application, if targeted at blind individuals, or printed in Braille if targeted at individuals who are both Deaf and blind.

Description

The descriptive transcript for a video, is a text file containing both the audio information (the one covered by the captions) and the visual information of the video, usually in a table format like the one bellow.

Audio	Visual
(narator) A colour-blind artist claims to have successfully implanted an electronic chip into his skull that allows him to "hear" colours.	The video plays in shades of gray. A young man walks on the sidewalk. A thin black antenna-like tube hangs over his head, starting at the back, passing over his hair and ending near his forehead, just above his eyes.
Neil Harbisson was born with a rare condition which means he only sees in black and white. He has become the first person in the world to have a cyborg antenna implanted in his skull.	The man is now in an art exhibition, standing in front of a painting. The camera focuses on the painting and the video is now in full color. The painting he observes, is colourful

Table 2: Sample from the descriptive transcript file. Audio and Visual information is presented in two separate columns and organized in logical segments / rows

Another type of descriptive transcript, is the one called "interactive". This very similar to a caption file, since it is also time-stamped. Interactive transcripts can be used instead of (plain) captions, to be displayed synchronized with the video content. In this case they can provide accessibility options to Deaf or hard of hearing individuals.

Some critical points in creating descriptive transcripts are the following (WAI, 2019b):

• **Put the information in logical paragraphs, lists, and sections**. If you're starting with a captions file, you will probably combine several lines into paragraphs.
• **Add navigation and clarifications**. Add headings and links where it will make the transcript more usable. It is generally acceptable to add clarifying information, as long as it is clear that it is not part of the actual audio — for example, words added to a paragraph put in [brackets], or separate sections with headings
• **Indicate the speakers based on the type of content**. For example: When there are multiple speakers, you could use hanging indents to make it easy to skim for a particular speaker.
• **Include timestamps only when useful**. In many cases, including timestamps would be unnecessary clutter. If you do include them, they usually don't need to be as granular as the captions, and do not need to include end times.

- **If starting with captions for video**: The video might have text information that was not included in the captions, for example, the title of the video or the name and title of individuals speaking. If you also have the description of visual information, it should already be in there. If not, you'll need to review the video and see if there is text visually that wasn't repeated in the captions, and add that to your transcript.

Development procedure

A video descriptive transcript can be created from scratch, by watching the video and typing all necessary information.

In the case of an already existing caption file, the process can be accelerated, by acquiring the audio information from the caption file, and just add the visual information description. This second approach was followed in our case, since we already had the caption file created.

For the creation of the transcript, a new document was created in Word, having two columns (Table 2). The information is also organized in rows, following a logical segmentation, depending on the information presented in the video.

Materials

This material (in English), is related to the deliverable D.2.1 of the project and is the document file titled *"d - How a cyborg artist 'hears' colours.description_en.docx"*.

The respected file was additionally created in Greek, in order to be useful to the Greek speaking audience and also be used for the pilot tests (D.2.2). The corresponding video file for Greek Speaking audience is *"d - How a cyborg artist 'hears' colours.description_gr.docx"*.

References

Berk, L. E. (2018). Development through the lifespan (7th edition). Hoboken, NJ: Pearson Education, Inc.

DCMP (2020). About the Described and Captioned Media Program. Retrieved on 8th May, 2020 from https://dcmp.org/about-dcmp

FCC. (2020). Closed Captioning on Television. Retrieved on 8th May, 2020 from https://www.fcc.gov/consumers/guides/closed-captioning-television

Green, J. L. (2018). Assistive Technology in Special Education: Resources to Support Literacy, Communication, and Learning Differences (3rd edition). Waco, Texas : Prufrock Press, Inc.

Microsoft (2020). Retrieved on 20th April, 2020 from https://support.microsoft.com/en-us/office/make-your-word-documents-accessible-to-people-with-disabilities-d9bf3683-87ac-47ea-b91a-78dcacb3c66d?redir=0&correlationid=f8839df1-e881-45a4-9f17-1938a0ab30f5&ui=en-us&rs=en-us&ad=us&ocmsassetid=ha101999993#bkmk_winaltvisuals2019

Microsoft (2020). Retrieved on 10th April, 2020 from https://support.microsoft.com/en-us/office/make-your-powerpoint-presentations-accessible-to-people-with-disabilities-6f7772b2-2f33-4bd2-8ca7-dae3b2b3ef25)

Newby, T. J., Stepich, D., Lehman, J., & Russell, J. D. (2006). Educational Technology for Teaching and Learning (3rd Edition). Upper Saddle River, N.J. :Merrill, 2006.

Open Library (n.d.). Retrieved on 20th April, 2020 from https://www.openbook.gr/ekpaideysi-kai-anapiria/ April, 2020 from from https://daisy.org/info-help/document-archive/archived-projects/save-as-daisy-ms-word-add-in/

The DAISY Consortium (2020). Retrieved on 28th April, 2020 from https://daisy.org/activities/software/wordtoepub/

The DAISY Consortium (2020). Retrieved on 25th April, 2020 from https://daisy.org/info-help/guidance-training/reading-systems/thorium-epub-reader-quick-start-guide/

Soulis, S. (2013). Education and disability Soulis. Athens, National Confederation of Individuals with Disabilities (in greek).

W3C. (2008). Web Content Accessibility Guidelines WCAG 2.0. Retrieved on 8th July, 2019 from http://www.w3.org/TR/WCAG20/

WAI. (2019a). Making Audio and Video Media Accessible. Retrieved on 8th May, 2020 from https://www.w3.org/WAI/media/av/

WAI. (2019b). Transcripts. Retrieved on 5th May, 2020 from https://www.w3.org/WAI/media/av/transcripts/

WAI. (2020). About W3C WAI. Retrieved on 8th May, 2020 from https://www.w3.org/WAI/about/

WGBH (2020). CADET - Caption and Descriptive Editing Tool. Retrieved on 8th May, 2020 from https://www.wgbh.org/foundation/what-we-do/ncam/cadet

Wikipedia (2020). Closed captioning. Retrieved on 8th May, 2020 from
https://en.wikipedia.org/wiki/Closed_captioning

Wikipedia (2020). Sign language. Retrieved on 8th May, 2020 from
https://en.wikipedia.org/wiki/Sign_language

Table of Figures