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Business Case White Paper Series  
e-Accessible  
Knowledge



Global Initiative for Inclusive Information  
and Communication Technologies



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# e-Accessible Knowledge

**A G3ict Business Case White Paper Series**

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Spring 2016



## Acknowledgments

This G3ICT White Paper picks up and builds on the topics addressed at the 9th European e-Accessibility Forum, held on 8 June 2015 at the Cité des Sciences in Paris. Over 250 professionals, association members and scholars from around the world gathered on this occasion to discuss “e-Accessible Knowledge”. Ten of the conference speakers and one further expert, all actively involved in e-Accessibility, have accepted the invitation to update the opinions and points-of-view expressed on this occasion in order to shape a review on this question.



BrailleNet



G3ict wishes to express its sincere appreciation to the organizers of the e-Accessibility Forum, Universcience and BrailleNet for making the proceedings of the European e-Accessibility Forum available for publication by G3ict and to Dominique Burger and Katie Durand for their invaluable editorial contributions in developing the concept of this white paper.

## About G3ict

G3ict is an advocacy initiative launched in December 2006 by the United Nations Global Alliance for ICT and Development, in cooperation with the Secretariat for the Convention on the Rights of Persons with Disabilities at UNDESA. Its mission is to facilitate and support the implementation of the dispositions of the Convention on the Rights of Persons with Disabilities (CRPD) promoting digital accessibility and Assistive Technologies. Participating organizations include industry, academia, the public sector and organizations representing persons with disabilities. G3ict organizes or contributes to awareness-raising and capacity building programs for policy makers in cooperation with international organizations, such as the ITU, ILO, UNESCO, UNITAR, UNESCAP, UN Global Compact and the World Bank. In 2011, G3ict launched the M-Enabling Summit Series ([www.m-enabling.com](http://www.m-enabling.com)) to promote accessible mobile phones and services for persons with disabilities and seniors, in cooperation with the ITU and the FCC (U.S. Federal Communications Commission). G3ict produces jointly with ITU the e-Accessibility Policy Toolkit for Persons with Disabilities ([www.e-accessibilitytoolkit.org](http://www.e-accessibilitytoolkit.org)), as well as specialized reports which are widely used around the world by policy makers involved in the implementation of the CRPD. G3ict is funded by contributions from corporations and foundations. Its programs are hosted by international organizations, governments, universities and foundations around the world.

For additional information on G3ict, visit [www.g3ict.org](http://www.g3ict.org)

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# Foreword

Knowledge is a key driver of social and economic development. It helps shape individual and collective identity and can be a tool for empowerment and inclusion.

Its production, dissemination and acquisition continue to gain currency in our information-rich society, and economic growth is increasingly determined by society's capacity to transform learning outcomes into quality goods and services.

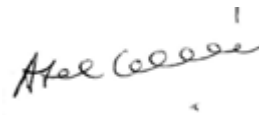
In this context, disparities in capacity to access and use knowledge can greatly hinder the development of an inclusive society and become a significant source of inequality. While important progress has been made through assistive technologies and accessibility standards elaborated by major stakeholder's consortia such as W3C, IDPF and DAISY, persons with disabilities are still at risk of exclusion, from education in particular. Rapid changes in the fields of consumer technology and publishing, however, are transforming the educational ecosystem and the growth of digital and multisensory resources provides a unique opportunity to cater for the needs of millions of individuals who are unable to access printed material. Providing they are used appropriately and according to agreed standards, emerging ICTs can help overcome visual impairments, physical disabilities, or learning differences and greatly enhance access to knowledge for all.

This G3ict White Paper presents and discusses:

- The need for customizable educational environments which adapt to diverse learning styles, abilities, preferences, and needs;
- The importance of working with existing international standards that are accessible, interoperable, sustainable and recognized by industry;
- How existing legislation can be used to challenge some of the mainstream technology and content vendors who fail to provide integrated access to their products and services;
- Scalable technology solutions that are being developed to enable content producers and education providers to produce accessible publications at source, even for particularly complex content;
- How some digital content producers are adapting their production processes to take advantage of the efficiency and interoperability that accessible standards provide;
- How accessible content, learning environments and assessment methods can benefit all students, regardless of disabilities or learning differences.



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# Preface



**By Axelle Lemaire, French  
Minister for Digital Affairs**

One of my goals since joining government has been to deliver on our commitment for greater equality through digital technology. I am doing everything in my power to ensure that technology brings empowerment and does not lead to additional discrimination and social exclusion.

An increasing number of our administrative procedures are performed online. This saves time and boosts productivity for those who are comfortable using computer hardware and software. But it can pose a genuine problem for those who do not have access to or do not know how to use either.

At a time when everyone is talking about “digital by default”, my aim is to promote “accessible by default”. Digital accessibility is not just about making websites and IT applications available to a certain group of disabled users. The real goal, which deserves most attention, is to ensure that the communication tools that we use are more far-reaching.

To this end, I am working closely with Ségolène Neuville, Deputy Minister for Disability and Social Exclusion Issues and Clotilde Valter, Deputy Minister for State Reform and Administrative Streamlining.

We have begun by updating the General Government Accessibility Guidelines (RGAA) to ensure they reflect the latest technological developments in the fast-moving IT world. Particular focus has been placed on ensuring that public stakeholders have at their disposal the resources required to optimize digital accessibility.

Furthermore, we must do everything we can to ensure that software developers are aware of digital accessibility and trained to take it into account. With this goal in mind, the government has signed a charter with public and private further education schools to ensure that digital accessibility is included in their curriculum.

From a European perspective, I have been paying very close attention to the work being carried out on the proposal for a Directive on the accessibility of the public sector bodies’ websites, and I visit Brussels on a regular basis to argue in favor of a Directive with a wider scope.

Lastly, my Digital Republic bill, which passed its first reading at the National Assembly on 26 February 2015, includes proposals to promote digital accessibility.

Article 43 aims to guarantee access for the deaf and hard of hearing to a telephone hotline service by offering a simultaneous and visual written translation relay service.

Article 44 covers accessibility to public communication services. It will require public service entities to disclose their level of compliance with accessibility standards. Failure to do so will result in their being fined. In addition, they must draw up a timetable over several years explaining how their digital services will be made available.

Given the progress already made and the work that lies ahead, it was an honor for me to attend the 9th European e-Accessibility Forum organized by BrailleNet and the Cité des sciences et de l’industrie on 8 June 2015. I was able to see at first hand the wealth of projects and achievements of universities and public libraries.

None of this would have been possible without the long-term joint efforts of Brailletnet, the Daisy Consortium and the International Digital Publishing Forum (IDPF). I would like to take this opportunity to thank and congratulate all of them for their hard work and commitment.

You can rely on my continued support. Thank you very much.



## Framing e-Accessible Knowledge

# The stick, the carrot, and cozying up: A litigation and legislative strategy for making e-accessibility the default in American post-secondary education

**Despite solid federal laws in the US that require higher educational institutions to provide equal access to their programs and activities, students with disabilities are not always given access to the same technology and materials as their peers. What are the reasons for this and what efforts need to be taken to make colleges and universities sit up, take notice, and make provision for integrated access to their programs and activities?**



**By Daniel Goldstein, Attorney, Brown, Goldstein & Levy (Baltimore, Maryland)**

Daniel Goldstein became involved in the field of disability rights law nearly twenty-five years ago at the behest of the National Federation of the Blind (NFB). After successful agreements reached with Apple, eBay, Ticketmaster, and Amazon on the accessibility of their websites, Dan helped form the Reading Rights Coalition in February 2009, bringing together 30+ organizations representing persons with print disabilities. The goal of the RRC was to make mainstream digital book devices, applications, and content accessible. As part of that work, Dan represented the NFB in a suit against Arizona State University over its Kindle pilot program and filed complaints with the Department of Justice against five other schools with similar programs. Since then, Dan or members of his firm have been involved in reaching agreements with Florida State University, Penn State University, University of Montana, Atlantic Cape Community College, Maricopa Community College, and the Seattle Public School System to make their digital curricular content and instructional technology accessible.

## Legal obligations

The scope of American law as it applies to accessible content and educational technology in American education shapes the strategy to have equal access for all. Federal (national U.S.) law, namely the Americans with Disabilities Act (ADA)<sup>1</sup> and the Rehabilitation Act<sup>2</sup>, requires that higher educational institutions provide equal access to their programs and activities. Thus, students with disabilities are entitled to the same information and to engage in the same transactions with equal timeliness and with a substantially equivalent ease of use. Separate access is permitted only when integrated access is not feasible. Separate access, for example, might include tactile graphics that replace informational non-textual materials that cannot be described adequately with words or numbers. Similarly, if the teacher writes on the board during class, blind students should have an accessible version of the teacher's notes in advance of class in order to be able to follow along with the rest of the class.

These laws are not new. The Rehabilitation Act has been in effect since 1974; the ADA, since 1990. But most universities are in violation of the law. Why? Firstly, the acquisition and distribution of digital content on campus, the control of websites and the acquisition of educational technology is completely decentralized, so that, in the absence of leadership by college presidents whose attention is typically elsewhere, no concerted effort is made to ensure that educational electronic information technology and digital content is accessible. Secondly, no national law imposes liability on publishers of post-secondary educational content or on the developers of educational technology. In the absence of a market demand, they are not motivated to address accessibility. Thus, the end game for the disability community is to create a market where accessibility is a positive competitive factor by motivating the educational institutions to demand accessibility from within and with third party vendors.

1. <http://www.ada.gov/>  
2. <https://www.disability.gov/rehabilitation-act-1973/>

## The stick

College presidents are like firefighters, they respond to that which is urgent. Suing colleges and universities can get the attention of college presidents, especially when the suit seeks court orders (injunctions) that tell them how they must conduct their business. The National Federation of the Blind (NFB) has funded suits brought by blind students, has brought suits in the name of the NFB itself, and has filed complaints with the Departments of Justice and Education, requesting them to bring suits or resolve complaints against universities. The suit against Atlantic Cape Community College resulted in a consent decree requiring the institution to develop accessible procurement policies, remediate its website, survey the accessibility of its current instructional technology and digital content and come up with a plan to replace the inaccessible with the accessible. A blind student, Aleeha Dudley, and the United States have jointly sued Miami University of Ohio, seeking similar relief.

These efforts have resulted in some very positive outcomes that require colleges to adopt evidence-based procurement policies. These policies require not only that digital content and services be accessible, but also that employees receive training on the creation of accessible content, that audits are undertaken to determine what technology the school is using and whether it is accessible, and finally that colleges adopt an action plan that is affordable and reasonable for replacing inaccessible content and technology with accessible content and technology.

These lawsuits and complaints are forcing colleges and universities to pay attention and, as a result, tech and content vendors are beginning to do so as well. As an example, one college in Philadelphia hired an accessibility consultant and spent three years adopting comprehensive accessibility policies so that they would not be sued. We have also used some state laws to incite tech vendors to address inaccessibility directly, notably, by pressing Apple, in conjunction with the Massachusetts Attorney General, to make iTunesU accessible. The results of that effort were spectacular, as Apple took accessibility to heart and developed fine accessibility tools for the iPhone3, the iPad and other iOS products. Recently, the NFB spoke up on the accessibility barriers in the Kindle File Format when the New York City Board of Education announced its intention to enter into a \$30 million contract for Amazon to create a virtual bookstore for students and teachers. That contract is now in limbo and may motivate Amazon to address those issues.

## The carrot

The NFB hosts summits and gives technical advice to textbook publishers, tech vendors and colleges and universities that request assistance. The NFB is planning to expand these efforts with online resources for these entities and for students. In addition, NFB and its representatives appear at conferences, often with government officials, to explain what to do and how to do it. The Tennessee Board of Regents, the second largest school system in the United States, held a three day training course on these issues for its top administrative leaders and invited other Tennessee colleges to participate. A leading publisher of textbooks for higher education is revamping its digital publications to make them fully accessible.

## Cozying up

So many schools, so many university presses and other publishers and so many tech vendors have no basic understanding of accessibility. And when a tech vendor tells a school that a particular technology is accessible, the typical school has no idea what accessible means. So the NFB, in conjunction with the American Council on Education, the Association of American Universities and other lobbying groups for higher education, are working together to agree on a best practices document to guide institutions. The NFB is also seeking to introduce legislation that would authorize the creation of a commission responsible for identifying accessibility standards for higher education. This would obviously include such standards as WCAG 2.0 AA and accessible EPUB3, but also standards for authoring tools, software, tactile graphics and suchlike. With all interested parties supporting a joint draft, the likelihood of passing legislation through an otherwise paralyzed Congress is quite high.

## Conclusion

It is not technological hurdles that are stalling the provision of accessible materials in higher education. Although more can be done to automate the process of providing accessible alternatives for non-textual information, the solutions already exist. The issue is rather down to market adoption. With liberal use of the carrot, the stick and cozying up by disability consumer groups, like the National Federation of the Blind and the National Association of the Deaf, with active support from the Departments of Justice and Education and certain state Attorneys General, success can be achieved.

## Learning Points

- Under the terms of the Americans with Disabilities Act and the Rehabilitation Act, higher educational institutions in the US are required to provide equal access to their programs and activities.
- A number of cases brought against the Departments of Justice and Education have prompted the higher education institutions concerned to improve the accessibility of their digital content and technology. State laws have also been used to challenge some of the mainstream technology and content vendors who fail to provide integrated access to their products and services.
- A group of national stakeholders, including the NFB, the American Council on Education and the Association of American Universities, are working toward generating a “best practices” document to guide higher education.
- Collective efforts to inform support and guide educational institutions in their provision of digital content will not only improve accessibility of educational programs and activities, but also incite tech vendors to write accessibility into their products and services at source.

## Framing Accessible Technology

# The EDUPUB Alliance and EPUB for Education - Building a Global, Accessible, Interoperable Educational Ecosystem

**In our rapidly evolving educational environment, the need for interoperable and accessible standards has never been so critical. In order to tailor existing standards to the needs of an increasingly ubiquitous and interactive educational ecosystem, standards bodies and industry specialists came together in 2013 to form the EDUPUB Alliance.**



### By Bill Kasdorf, VP and Principal Consultant, Apex Content Solutions

Bill Kasdorf is Vice President and Principal Consultant of Apex Content Solutions. He is a member of the Board of Directors of the International Digital Publishing Forum (IDPF) and is active on its EPUB Working Group; chairs the Content Structure

Committee of the Book Industry Study Group (BISG); and is an active member of the W3C Digital Publishing Interest Group, the IDEAlliance Technical Council, the Society for Scholarly Publishing (SSP), and the International Press Telecommunications Council. He is a recipient of SSP's Distinguished Service Award, the IDEAlliance/Digital Enterprise Education & Research (DEER) Luminaire Award, and the Book Industry Study Group's 2014 Industry Champion Award.

As education moves beyond books to bits, and the educational experience expands beyond the classroom to cyberspace, it becomes ever more critical to educators and students, and all those who serve them, that the educational ecosystem be interoperable.

Educational publishers are transforming from product-focused operations to platform-focused operations. Educators are less reliant on monolithic textbooks, expanding their scope to resources in many media available from many sources. The learning experience is ever more individualized, with teachers able to assess and monitor each student's progress and, with the help of sophisticated systems, target the educational experience accordingly.

Educational resources don't just come neatly packaged in textbooks anymore. Students and teachers need a multitude of resources—books, chapters, articles, media, quizzes, exercises, models, data, and more—and they need to use them online and offline, alone or collaboratively, on whatever device they choose. But when the systems producing and delivering those educational resources are proprietary, and when the resources themselves are not interoperable and accessible, there is tremendous waste and friction.

## The EDUPUB Alliance

To address this problem, the EDUPUB Alliance was formed in 2013. A deliberately loose confederation—initially comprising the IDPF (the International Digital Publishing Forum, the organization responsible for the EPUB standard for portable, accessible documents based on Web standards)<sup>3</sup>, IMS Global (the organization responsible for standards like QTI (Question & Test Interoperability)<sup>4</sup>, LTI (Learning Tools Interoperability)<sup>5</sup>, and Caliper Analytics<sup>6</sup>, and the W3C (the World Wide Web Consortium, responsible for key web standards such as HTML (Hyper Text Markup Language), XML (Extensible Markup Language), CSS (Cascading Style Sheets)<sup>7</sup>, and many others), joined by the BISG (the US Book Industry Study Group)<sup>8</sup> and a number of educational publishers such as Pearson, Wiley, and O'Reilly. The EDUPUB Alliance set out to establish an open, accessible, standards-based educational technology ecosystem.

A key concept behind EDUPUB was to not create a new standard. Instead, the vision was to build on existing standards, making them increasingly interoperable, and developing profiles and specifications optimized for education. The vision is global and accommodating: EDUPUB is designed to enable publishers, educators, and students anywhere in the world to align their systems and practices to work well together.

3. <http://idpf.org/>  
 4. <https://www.imsglobal.org/question/index.html>  
 5. <https://www.imsglobal.org/activity/learning-tools-interoperability>  
 6. <https://www.imsglobal.org/activity/caliperram>  
 7. <https://www.w3.org/>  
 8. <https://www.bisg.org/>

Most importantly, EDUPUB is designed from the ground up to be accessible. It is based on the fundamental principle that educational resources and systems should be fully functional for all learners of all abilities. The benefits of this are transformational: making content and systems accessible makes them better for everybody.

## EPUB for Education

The first major EDUPUB initiative was to develop a profile for EPUB 3 optimized for education. Initially called EDUPUB and now named EPUB for Education, it was developed under the auspices of the IDPF EPUB 3 Working Group and involved a broad cross-section of contributors, including publishers, technology companies, platform and service providers, and others from around the world.

EPUB was chosen as the optimum format in which to deliver educational content for a number of reasons.

- It is a completely free, open, non-proprietary standard;
- It is based on web standards, which have become fundamental to the creation and dissemination of content in digital forms;
- It is a global standard, implemented in a broad range of languages worldwide;
- It is for all types of publications and media;
- It provides a format that adapts to a wide range of devices, from desktops and laptops to tablets and smartphones;
- It is designed to be accessible and is endorsed by the DAISY Consortium as the format in which to deliver accessible digital content.

It's important to recognize that EPUB is not just for books. EPUB for Education is intended for all types of content, from books and articles to videos, exercises, quizzes, and all types of multimedia and interactive content.

EPUB for Education does not require publishers to re-engineer their production systems, although several major educational publishers are currently doing just that, to take advantage of the efficiency and interoperability that it provides.

It does not require schools, educators, or students to acquire particular proprietary software or systems. Schools should be able to use the learning management systems they've already invested in. Educators should be able to use resources from any publisher who can supply those resources as EPUB. Students should be able to access those resources on whatever device they choose, whenever and wherever they need to.

Most importantly, content delivered as EPUB for Education should be inherently accessible, enabling the use of assistive technology by those who need it, without the delays and costs currently associated with providing accessible content. All students should be able to get their content in the same form and at the same time.

That's the vision. And significant progress is being made to realize that vision.

## What Makes EPUB for Education Special?

While being in every respect a valid EPUB, an EPUB for Education file conforms to certain specifications for document structure, vocabulary, metadata, and accessibility optimized for education.

For example, it defines a teacher edition, that is to say a superset of the student edition with teacher-specific content, and a teacher guide that is supplemental. It requires certain HTML markup for proper structure and navigation, and recommends page break markers when there is a corresponding print or paginated rendition, so that students using print, digital, or assistive technologies can stay in synch. It provides standardized terms for learning objectives, assessments like tests and quizzes, and activities like practice exercises. It specifies how to implement an EPUB for Education with systems using IMS Global's LTI (Learning Tools Integration) specification.

The development of EPUB for Education contributed to some advances to the basic EPUB specification as well. For example, it led to a specification for Scriptable Components, the 'widgets' and other features that are often used for interactive exercises and assessments. It led to a spec for Distributable Objects, which enables components of a publication—chapters of a book, a set of exercises, a video, a test—to be extracted from their parent EPUB and distributed independently as valid EPUBs for Education.

## Is EPUB for Education Ready for Use?

While its development is intentionally agile and iterative, enabling it to respond to future developments and to what is learned from initial implementations, EPUB for Education (then called EDUPUB) has been considered feature complete since July 2015 with the version published by IDPF. This specification is already the basis for implementations by several major publishers. The second public draft of the EPUB 3 EPUB for Education profile will add full conformance criteria for IMS LTI integration, and was published in February 2016 at <http://www.idpf.org/epub/profiles/edu/spec/>.

Most importantly, because EPUB for Education completely conforms to the EPUB 3 specification, any vendor or system that understands or uses EPUB 3 can produce or consume EPUB for Education-conformant content. The EPUB 3 specification is currently being updated to EPUB 3.1. This update will streamline the specification, integrating aspects that are separate 'satellite' specifications to the current EPUB 3.0.1, deprecating features that have not been found to be useful, simplifying the metadata in an EPUB and enabling domain-specific metadata records to be associated with it in a more dynamic way, and making a variety of small but backwards-compatible improvements to take advantage of recent developments, such as the ability—now native to HTML5—to enrich content semantically. Most importantly, EPUB 3.1 will tighten up the requirements for accessibility.

IDPF plans to develop a certification that will not only check whether a publication is a valid EPUB, but whether it meets additional requirements to make it a high-quality EPUB, providing appropriate accessibility features and, if it declares itself to be an EPUB for Education, conforming to that profile as well.

EPUB for Education is a prime example of the convergence of technologies we're experiencing at present: the standards of the Open Web Platform, including those for accessibility, provide the foundation for EPUB which has now been optimized for education. We all benefit from broad, open collaborations like the EDUPUB Alliance.

### Learning Points

- Educational publishing is no longer restricted to one-size-fits-all textbooks; customizable multimedia resources are now required for use on and offline on multiple platforms and devices and as such need to be fully interoperable and accessible.
- The EDUPUB Alliance was created in 2013 to bring together standards bodies and industry groups in an effort to tailor existing standards to the very broad and evolving needs of the educational sector.
- The development of EPUB for Education has contributed to the overall evolution of the basic EPUB specification.
- The IDPF published a feature-complete version of the EPUB for Education specification in July 2015 (then called EDUPUB). A new version incorporating further standards has been published in February 2016.
- The IDPF plans to develop a certification program for all EPUB files that will test for the provision of accessibility features.

## Making Complex Content Accessible

# Accessible Scientific Content: Challenges and Prospects

It is often claimed that the move to digital has increased the number of books available to the print disabled. While this is indeed the case for general literature (novels, short stories and essays), accessible scientific publications – which include books, journals, theses, lecture notes and databases – are still few and far between. This scarcity is primarily down to the complexity of scientific publications which marks the entire information chain, from production to distribution and restitution. The growth of digital resources, however, has the power to dramatically improve the amount of scientific material available, whether specialized or directed at the general public.



### By Alex Bernier, Technical Director, BrailleNet

Alex Bernier studied computer engineering at the National Institute of Applied Sciences (INSA) in Rennes. He has worked on various projects related to books and digital libraries. He is responsible for the Accessible Francophone Digital Library (BNFA) and a research and development program aimed at improving the accessibility of scientific and technical documents for the visually impaired.

## The need for equal access to science

The acronym STEM refers to the academic disciplines of science, technology, engineering, and mathematics<sup>9</sup>. According to the U.S. Department of Commerce, Economics and Statistics Administration, 'over the past 10 years, growth in STEM jobs was three times as fast as growth in non-STEM jobs. STEM workers are also less likely to experience joblessness than their non-STEM counterparts'<sup>10</sup>.

To be afforded equal opportunities, particularly in the fields of education and employment, every citizen needs to be given access to scientific content – whether it be in books, journals, theses, lecture notes and databases – as a matter of urgency. In addition to providing access to education and employment, scientific literacy is a tool for empowering people as it fuels political, social and economic debate.

However, for a great many students, professionals and members of the general public with disabilities, countless barriers prevent full access to scientific and technical publications. It is estimated that only 8 to 10% of published materials are accessible to print-disabled people<sup>11</sup>, but this figure drops drastically when considering STEM content.

## The challenges of adapting scientific content

In addition to structured text, STEM content tends to include diagrams, formulae and illustrations. These graphical elements are often essential to understanding the concepts or examples presented in the text. Visual representations are based on a variety of conventions that tend to be two, or sometimes three dimensional. Mathematical formulae, chemical diagrams, charts and graphs rely on color and rich visual components to both represent and differentiate between data. These visual components rarely follow agreed standards but tend to be the result of a subjective choice made by the author.

Figure 1 illustrates the variety and complexity of visual representations in STEM publications.

<sup>9</sup>. Some give a broader definition of STEM to englobe many other disciplines including geology, economy, social sciences, psychology and music.

<sup>10</sup>. [http://www.esa.doc.gov/sites/default/files/stemfinaljuly14\\_1.pdf](http://www.esa.doc.gov/sites/default/files/stemfinaljuly14_1.pdf)

<sup>11</sup>. Report by the World Blind Union, <http://www.worldblindunion.org/English/our-work/our-priorities/Pages/right-2-read-campaign.aspx>



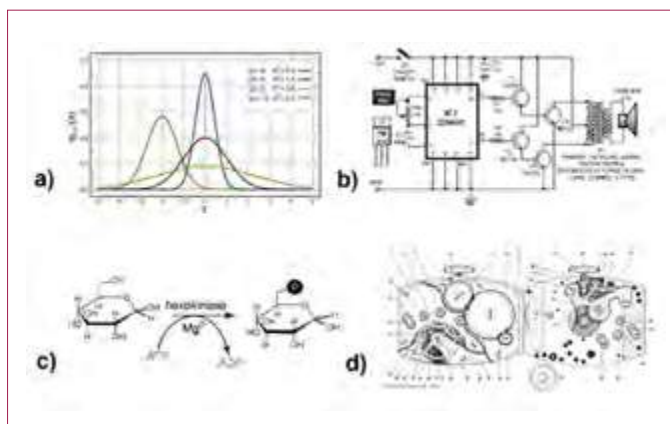


Figure 1: Examples of STEM graphics a) line graph; b) electronic diagram; c) chemical formula; d) mechanical diagram.

## Creating accessible alternatives

A print disability, such as a visual impairment, a cognitive or learning disability, or a physical disability can prevent access to published works, especially in print, and may require the use of alternative methods to access the information contained within. Provided they follow accessibility guidelines, digital formats can be read by assistive technologies such as Braille displays, enlargement software and text-to-speech software. Table 1 gives some examples of the adaption and the technology necessary to access digital content in alternative formats. It is by no means comprehensive but gives an idea of the range of techniques used. It is also worth noting that users are sometimes required to use a combination of techniques.

## Developing standardized formats and production tools

A number of formats, including LaTeX, MathML, CML, SVG schemas, DAISY and EPUB 3, have been built to accommodate accessibility in STEM content at source. There are also a handful of tools that have been developed to produce accessible content using these formats. Examples that will be touched upon in the following articles of this white paper include Optical Character Recognition (OCR) applications that recognize and transcribe scientific documents, such as InftyReader<sup>12</sup>; MathType, an interactive equation editor for Windows and Macintosh developed by DesignScience; LibreOffice Equation Editor<sup>13</sup>; and DIAGRAM's Poet, an open-source, web-based tool for creating image descriptions for images in existing DAISY and EPUB books<sup>14</sup>.

## Building a unified production chain

### Organizational and economical challenges

The visual and conceptual complexity of STEM content goes some way towards explaining the sparsity of accessible resources. The few resources that do exist have been produced in an ad hoc and artisanal fashion, are inconsistent in quality and are characterized by ill-defined semantics.

Content Type	Adaptation Required	Technology Used to Access Content	Disability Effected
1. Text	Mark-up of structured text using the HTML, XML or EPUB3 standards in alignment with accessibility guidelines	Braille displays, enlargement software and text-to-speech software	Blindness, low vision, learning disabilities
2. Images / Diagrams	Alternative text descriptions	Braille displays, enlargement software and text-to-speech software	Blindness, low vision, learning disabilities
3. Images / Diagrams	Tactile 2D graphics, 3D diagrams	Imaging software, swell paper and standard printer (2D graphics), 3D printer	Blindness, low vision, dyspraxia, learning disabilities
4. Line Graphs	Tactile 2D graphics, 3D diagrams	Imaging software, swell paper and standard printer (2D graphics), 3D printer	Blindness, low vision, dyspraxia, learning disabilities
5. Line Graphs	Sonification	Data-to-sound mapping software, audio output	Blindness, low vision, learning disabilities
6. Math Formulae	Math Braille	Braille display	Blindness
7. Math Formulae	Mark-up of structured formulae using the HTML, XML or EPUB3/MathML standards in alignment with accessibility guidelines	Braille displays, enlargement software, text-to-speech software, reading tools capable of navigating within formulae	Blindness, low vision, dyspraxia, learning disabilities
8. Chemical Formulae	Alternative text description	Braille displays, enlargement software and text-to-speech software	Blindness, low vision, learning disabilities
9. Chemical Formulae	Mark-up of structured formulae using the CML standard in alignment with accessibility guidelines	Braille displays, enlargement software and text-to-speech software, reading tools capable of navigating within diagrams	Blindness, low vision, dyspraxia, learning disabilities

<sup>12</sup> <http://www.inftyreader.org/>

<sup>13</sup> <https://wiki.documentfoundation.org/images/3/37/MG40-MathGuide.pdf>

<sup>14</sup> <http://diagramcenter.org/development/poet.html>

Agencies who adapt STEM content are required to work with professionals who have a background in science and are capable of interpreting complex data. In practice, these professionals tend to solve access problems on a case by case basis. They are unable to rely on automated and semi-automated adaptation tools and costs quickly escalate as a result. A limited knowledge of accessible formats and associated production tools only exasperates the complexity of the task.

For these reasons, despite the emergence of accessible and standardized formats, content producers and publishers are struggling to establish unified and seamless production chains for producing accessible scientific publications. As readers of STEM content are theoretically fewer than those of mainstream literature, adaptation agencies in turn tend to prioritize the latter in their production programs.

### Technical challenges

While robust production tools, such as those cited in this paper, do exist, a great many more solutions fall short of fully addressing accessibility requirements. Often developed within the remit of a research project, some tools are not powerful enough to be deployed in real life situations. Maintenance and development also proves problematic as project teams struggle to find the resource or budget to ensure their solutions are sustainable beyond the project lifecycle.

For those solutions that do make it possible to create accessible scientific content at source, there are currently only a few reading tools, such as Design Science's MathPlayer<sup>15</sup>, that are able to take full advantage of this content and offer readers a comfortable reading experience. Without provision for this vital step in the information chain, people with disabilities will not be able to access scientific content on an equal footing.

### Prospects

In order to build more robust and sustainable production chains from a technical point of view, development teams need to fully integrate standards such as MathML into their solutions. They also need to concentrate efforts on the development of powerful reading tools that can be directly integrated into web browsers and screen readers.

Meanwhile, content producers and publishers need to familiarize themselves with accessibility requirements and be given sufficient training to become fully competent in the use of content production solutions that incorporate STEM adaptation tools.

In parallel, research and development teams need to explore further ways to increase access to STEM content, such as:

- The provision of innovative multisensory schemes combining tactile, haptic, audio and speech interaction with complex content;
- The potential of low cost 3D printers to improve the representation of scientific concepts;
- The development of collaborative tools and methodologies supporting communities in the adaptation of scientific material according to agreed standards.
- Ways to overcome copyright issues that currently hinder the adaptation of scientific content must also be explored.

### Learning Points

- Occupations associated with scientific disciplines have the most employment and projected job openings and growth. To be granted equal access to these jobs, people with disabilities need to be given equal access to scientific content as a matter of urgency.
- Visual representation is often used to express and support scientific information. It is the adaptation of this content that proves particularly challenging and goes some way to explaining the scarcity of accessible scientific publications.
- Content production tools based on standards such as MathML and CML are emerging, but at present there are very few reading tools that enable users to comfortably read adapted scientific content.
- Without agreed standards on how to adapt visual representations, robust content production tools and sufficient training, content producers and publishers will continue to struggle to produce accessible scientific publications at source, and adaptation agencies are likely to concentrate their resources on adapting general literature.

<sup>15</sup> <https://www.dessci.com/en/products/mathplayer/>



## Making Complex Content Accessible

# Born Digital = Born Accessible

## New Developments in Creation and Use of Accessible Materials in the DIAGRAM Center

Visual content—including complex scientific images, mathematical expressions, graphs, charts, maps, or diagrams—remains largely unavailable to people who cannot see the images or who have disabilities that make processing of visual information difficult or impossible. Through its federally-funded research and development initiative, the DIAGRAM Center, Benetech provides publishers and content producers with expertise, practical guidance and tools that will enable them to create “born accessible” digital material as an integral part of their publishing process.



### By Betsy Beaumon, President, Benetech

Betsy Beaumon is a technology executive, entrepreneur, and authority on digital accessible materials in education. She joined Benetech in 2009 as general manager of the organization's Global Literacy Program, spearheading it through a tremendous expansion in size and breadth of impact. She grew Bookshare, Benetech's accessible online library for people with print disabilities, into the world's largest library of its kind, and established Benetech as a leader in the accessibility field through its DIAGRAM Center and Born Accessible initiative. In 2015 she was named Benetech's president. Betsy serves on the board of the DAISY Consortium.

### Introduction: Toward Accessible Online Content

Rapid changes in the fields of consumer technology and publishing are transforming the content landscape and provide a unique opportunity to address the needs of millions of individuals who face barriers of access to information, such as those with visual impairments, physical disabilities, or learning differences. For the first time in history, people with print disabilities may be able to purchase and fully utilize an entire world of information, instantly upon publication.

As a pioneer in the field of information accessibility, Benetech<sup>16</sup> believes the time is right for the publishing world to seize this era of opportunity. Our experience is rooted in our work on Bookshare, Benetech's accessible online library for people with print disabilities. Bookshare<sup>17</sup> serves more than 360,000 members in over sixty countries with a collection of 375,000+ accessible titles, including trade books, textbooks, and magazines—the world's largest library of its kind. Thousands of titles are added to Bookshare's virtual shelves each month, and members can read them in the format and on the device of their choice. A major driver behind the collection's rapid growth is the ecosystem of over 600 publisher partners who voluntarily provide Bookshare with high-quality digital versions of their books. Bookshare also collaborates with other libraries and organizations, in the United States and internationally, to help shape accessible book delivery in the digital age.

Despite the shift to electronic distribution of published works, however, publishers and other content creators have to overcome key challenges to produce fully accessible materials, especially with visual information. As a nonprofit on a mission to empower communities in need by creating scalable technology solutions, Benetech believes that, in the field of accessibility, technological innovation can bridge the gap where human intervention is too expensive, too time consuming, and cannot keep up with the pace of production.

<sup>16</sup>. <http://benetech.org/>

<sup>17</sup>. <https://www.bookshare.org/cmshttps://www.dessci.com/en/products/mathplayer/>

Our work is therefore based on a simple premise: all content that is “born digital” must be “born accessible<sup>18</sup>,” that is, made universally accessible from the outset, as an integral part of the publishing process. To make this vision a reality, Benetech’s work has evolved to encompass the research and development necessary to make it easier to create, discover, use, and interact with the full array of accessible content.

## Accessible Publishing: Addressing the Challenge of Non-Text Content

While the move to eBook publishing and solutions like Bookshare address many of the challenges in making text accessible, visual content—including complex scientific images, mathematical expressions, graphs, charts, maps, or diagrams—remains largely unavailable to people who cannot see the images or who have disabilities that make processing of visual information difficult or impossible. Text descriptions may or may not be sufficient to convey the meaning of such complex images. Mathematical and chemistry notations present even further barriers to accessibility, for they must be specially encoded to be used with standard reading technologies.

Through a federally-funded research and development initiative called the DIAGRAM Center<sup>19</sup>, Benetech has spent the past five years building the technology and collaborative community to address these challenges. The Center’s charter is to make it easier, faster, and cheaper to create and use accessible digital images. It does so through its work in four areas:

- Standards<sup>20</sup>: ensuring that accessibility is an integral part of the content creation process
- Development<sup>21</sup>: building software tools that revolutionize the ways in which digital images are made accessible
- Research<sup>22</sup>: exploring emerging technologies for making accessible digital images
- Training<sup>23</sup> and Outreach<sup>24</sup>: offering free webinars, reports, and other resources on the latest innovations in the field of accessible publishing

The Center works in partnership with the U.S. Fund for DAISY, WGBH National Center for Accessible Media (NCAM), and a diverse community that includes dozens of technologists, educators, publishers, accessibility experts, students, and parents.

## Methods for Creating Accessible Images

Today, there are many ways to create accessible alternatives for visual content in a digital book. Following are some methods and technologies for creating such alternatives that the DIAGRAM Center and Benetech research and develop.

### Image Descriptions

Poet<sup>25</sup> is a free, open source, web-based tool for composing text descriptions for images in existing DAISY and EPUB books. With Poet, it is possible to crowdsource the creation of image descriptions, which can reduce both the cost for content creators and delivery time for readers and learners. Poet is often used as a training module<sup>26</sup> that offers hands-on practices to help cultivate skills for composing high-quality image descriptions.

### Tactile Graphics

Tactile graphics are image representations that use raised surfaces. They are often needed for conveying the meaning of charts, diagrams, schematics, and maps, primarily in digital books in the fields of science, technology, engineering, and math (STEM).

### 3D Objects

3D-printed models provide an affordable alternative to purely visual content. In educational settings, they have the potential to offer students across the widest range of learner variability a tactual mode of understanding spatial concepts. Benetech has been leading a project to identify new ways in which 3D printing in libraries and museums can be used to improve learning and accessibility, particularly in STEM disciplines. This project builds upon the DIAGRAM Center’s research into ways in which 3D printing technology can be applied to create accessible educational materials.

### Accessible Math

MathML Cloud<sup>27</sup> is a free, open source, cloud-based tool that automatically generates accurate images and image descriptions of mathematical expressions, to bridge the gap between nascent Mathematical Markup Language (MathML) production and the many reading tools with varying levels of math support. MathML Cloud generates the image that the publisher needs for display while also automatically generating the prose transcription for synthetic speech output, scalable vector graphics (SVG) for users who need to resize the image, and saving the MathML that the reader needs for full accessibility.

### Sonification

Sonification uses non-speech audio to convey information and help perceive it. Sonification is particularly useful in representing mathematical concepts (e.g., the behavior of a graphed equation), and can benefit all students, regardless of disabilities or learning differences.

### Accessible Interactive Widgets

A widget is a digital representation of information that allows user actions to change the information or its appearance (e.g., a circle with a radius whose values can be changed by selecting one of two radio buttons). The DIAGRAM Center explores best practices for making such dynamic scientific graphics accessible by, for instance, providing pedagogically-equivalent information about common scientific visualizations using audio feedback and verbal description.

<sup>18</sup> <http://bornaccessible.org/>

<sup>19</sup> <http://diagramcenter.org/>

<sup>20</sup> <http://diagramcenter.org/standards-and-practices.html>

<sup>21</sup> <http://diagramcenter.org/development.html>

<sup>22</sup> <http://diagramcenter.org/research.html>

<sup>23</sup> <http://diagramcenter.org/webinars.html>

<sup>24</sup> <http://blog.diagramcenter.org/>

<sup>25</sup> <https://diagram.herokuapp.com/>

<sup>26</sup> <https://diagram.herokuapp.com/training/index>

<sup>27</sup> <https://mathmlcloud.org/>

The DIAGRAM Center has produced an Accessible Image Sample Book<sup>28</sup> to help content producers to learn more about these and other options for creating accessible versions of digital images. This free, online resource offers guidance on understanding when and how to produce accessible images, along with real-world sample accessible images and the underlying code used to produce them.

## Looking Ahead

The United States Department of Education has recently extended its support of the DIAGRAM Center through 2020 with an expanded mission. In addition to addressing the needs of students with print disabilities, DIAGRAM Center + broadens its scope to include students with autism spectrum disorders, hearing impairments, intellectual disabilities, and other disabilities. It will conduct image accessibility research and development with multiple partners in areas including end-to-end accessible math, accessible image registry, metadata for discoverability of accessible images, and more.

### Learning Points

- Benetech believes that content should be made universally accessible from the outset, as an integral part of the publishing process.
- Through the development of standards, tools, training and resources, the DIAGRAM Center supports content producers in the creation of accessible images for print-impaired students.
- Text descriptions do not always manage to convey the meaning of complex scientific images, mathematical expressions, graphs, charts, maps, or diagrams. Tactile graphics, 3D objects, sonification and interactive widgets are some of the solutions that have been developed to help users perceive the content represented in complex images.
- With support from the United States Department of Education, the DIAGRAM Center will be extending its research to include students with a host of other disabilities.

<sup>28</sup> <http://diagramcenter.org/standards-and-practices/accessible-image-sample-book.html>

## Making Complex Content Accessible

# The State of Accessible Math

The last few years have seen tremendous advances in solutions that make mathematical equations accessible on desktop and mobile devices. Solutions designed to facilitate the content producers' task of creating accessible formulae following the W3C MathML standard are complemented by software and plug-ins that enable users to access these formulae as speech or Braille on a host of mainstream browsers and devices.



**Neil Soiffer, Senior Scientist,  
Design Science**

Dr. Neil Soiffer received his PhD in Computer Science from the University of California, Berkeley. He was a member of Tektronix's Computer Research Lab, where he created experimental math computation systems, math editors, and tools for embedded systems. Dr. Soiffer moved to Wolfram Research, where he was responsible for a number of user elements that are part of Mathematica, including the WYSIWYG<sup>29</sup> math editor and programmability of Mathematica's notebook interface. He joined Design Science in 2003 and has worked on math accessibility in their MathPlayer plug-in for Internet Explorer. Dr. Soiffer was a principal architect of MathML, and continues to have an active role in the W3C math effort.

## Introduction

We are at the start of what could be the golden age of math accessibility. In the last few years, a lot of progress has been made in making math accessible. There now exist accessible calculators and software that can make plots accessible. Moreover, properly encoded web pages are accessible on Apple devices, on Chromebooks and on Windows, using Assistive Technology (AT) from various vendors.

Most of these solutions support speaking math expressions<sup>30</sup>, synchronized highlighting of what is spoken, and interactive keyboard navigation of math. Some also support output of some Braille math codes such as Nemeth and Unified English Braille (UEB) on refreshable Braille displays. The focus of this paper is on how to make math expressions accessible. However, because there is much more to math than formulae, we begin with an overview of solutions for other aspects of math accessibility.

## Plots, Diagrams, Calculators and More

Two low-tech solutions for accessible plotting are:

- using tables for the data points;
- embossing the plot.

Embossing can also be used for diagrams. There are a few higher-tech enhancements to embossing such as the Iveo system from ViewPlus<sup>31</sup>. These systems require the user to place the embossed output either on a touch pad or under a camera so that when the user touches a spot on the plot or diagram, a computer provides additional information that does not easily fit on the embossed Braille.

An exciting alternative to embossing is 3D printing. 3D printers allow blind users to explore information that is more naturally presented in three dimensions. Even for 2D diagrams and plots, 3D printers can provide higher resolution than raised dots.

A more immediate solution for plotting is sonification of plots. Sonification typically represents the x-axis via the left and right stereo channels and the y-axis as a frequency. MathTrax<sup>32</sup> is a free program from NASA that allows users to enter expressions and hear the graph by using audio tones and cues. It gives a textual description that includes points of interest such as y-coordinate crossings. Along a similar line, Reach for the Stars: Touch, Look, Listen, Learn is an astronomy iBook for Apple devices that is fully accessible. The plots in the book allow for touch exploration and provide interactive auditory feedback including sonification on touch screen devices.

<sup>29</sup> WYSIWYG is an acronym for "what you see is what you get". It is an interface that allows a content creator to see what the end result will look like while the content is being created.

<sup>30</sup> These are spoken mostly in English, but Mac+Safari and MathPlayer support many other languages.

<sup>31</sup> <https://viewplus.com/product/iveo-hands-on-learning-system/>

<sup>32</sup> <http://prime.jsc.nasa.gov/mathtrax/>

Graphing calculators are based on a similar idea. One example is ViewPlus' Audio Graphing Calculator (AGC)<sup>33</sup> for Windows. A more recent introduction is a hardware addition by Orion to the TI-84 calculator. This addition uses a voice to speak the equation and also to speak data points on a graph. Alternatively, tones can be used for the data points.

## Accessible Equations

The main focus of this paper is making math equations such as  $c = \sqrt{a^2 + b^2}$  accessible.

### Images with alt text are not the answer

Up until recently, many web sites used images to represent math. The usual way to make images accessible is by adding alt text. For math this is a poor solution because:

- Math uses special Braille codes and those codes cannot be derived from alt text,
- Images do not magnify well when screen magnifiers are used,
- The alt text that is spoken cannot highlight the corresponding part of the math. People with vision-related learning disabilities such as dyslexia benefit from assistive technology that highlights the words that are spoken. A study found that comprehension error rates for dyslexic students reading math are twice as high as dyslexic students reading text<sup>34</sup>,
- For larger expressions, it is very hard to understand the math because people can only remember about seven words at once. Just as someone reading a table is likely to want to navigate the rows and columns in the table to better understand it, being able to move around the math in logical groupings helps people to understand the math.

### MathML is the answer

MathML is a W3C standard for publishing MathML on the web. It has been around for quite a number of years and has been included in many standards such as DAISY 3 and EPUB3. Its use on the web was less common until recently because it was an XML dialect and not part of HTML 4, the format most web pages used. However the most recent version of HTML, HTML 5, includes MathML.

This inclusion has helped spur development in browsers. Firefox and Internet Explorer (IE) together with the Design Science MathPlayer plug-in<sup>35</sup> have long supported MathML. More recently, Safari has added MathML support. Unfortunately, IE has moved away from supporting plug-ins. Because MathPlayer is a plug-in, it only runs in a legacy mode in current versions of IE. Fortunately, MathJax<sup>36</sup>, a JavaScript library, supports MathML in all browsers and defers to native rendering where appropriate. MathJax runs anywhere where there is JavaScript support, so almost all devices including Android and iPad tablets display MathML. The main exceptions are eBook readers which do not currently support JavaScript, such as Amazon's Kindle reader.

The ability to display MathML in almost every browser, along with MathML's inherent accessibility, has spurred many more sites to use MathML either directly or indirectly in the last couple of years. For example, Wikipedia delivers MathML for most of its math in pages if you sign up, login in and tell it to use MathML<sup>37</sup>. Another example is Kahn Academy<sup>38</sup>, a very popular tutoring site that includes videos and exercises for math and some science topics, which delivers MathML for AT. Many learning management sites such as Moodle<sup>39</sup> and question and answer sites such as Stack Exchange<sup>40</sup> also use MathML via MathJax.

Even more important than having accessible math is having Assistive Technology (AT) that can take advantage of that accessibility. In the last few years, great strides have been made. If you have an Apple device (Mac, iPad, iPhone), then Safari via VoiceOver will read, navigate, and output Braille for pages that use MathML. For Chromebooks, ChromeVox (works with the Chrome browser) will read and navigate the MathML. On Windows, JAWS 16 supports reading and navigating MathML. MathPlayer 4 can work with any AT to read, navigate, and generate Braille for sites that use MathML.

### MathPlayer 4: going beyond accessible web pages

MathPlayer 4 was released In March 2015. Like MathPlayer 3, Design Science continues to make it available for download free of charge. MathPlayer 4 is a library that can be called by any AT. It provides support for:

- converting MathML to speech;
- navigation within equations,;
- Braille math code (using Liblouis for the conversion).

It also helps to support synchronized highlighting of the speech and display. Because it is a library, if AT can extract MathML from a document, it can be read, navigated, etc. Design Science's MathType equation editor, which works in many Microsoft Office applications, supports conversion to MathML, so math in Word and PowerPoint can be made accessible.

At the time of MathPlayer's release, two AT solutions made use of MathPlayer:

- Windows-Eyes supports math in Word documents;
- NVDA supports math in Word, PowerPoint, IE, and Firefox. NVDA also supports math in PDF documents, but there are currently no tools that produce MathML for PDF documents, so that support is limited to mainly test pages.

<sup>33</sup> <https://viewplus.com/product/audio-graphing-calculator/>

<sup>34</sup> Preston Lewis, Linnie Lee, Steve Noble. April, 2013. KY Math Etext Project- A Case Study: Math Curriculum Digital Conversion and Implementation. In Information Technology and Disabilities Journal. EASI, Vol XIII, Num 1.

<sup>35</sup> <http://www.dessci.com/en/products/mathplayer/download.htm>

Initial support for MathPlayer was supplied in part via an NSF SBIR grant. Many of the newer features in MathPlayer were supported in part by an IES NCSEER grant (R324A110355). Lois Frankel and Beth Brownstein at ETS were my main colleagues on the IES grant. They did the hard work of setting up and running the MathPlayer evaluations along with co-developing the ideas for ClearSpeak.

<sup>36</sup> <https://www.mathjax.org/>

<sup>37</sup> Wikipedia expects to make this the default in the next year or two.

<sup>38</sup> <https://www.khanacademy.org/>

<sup>39</sup> <https://moodle.org/>

<sup>40</sup> <http://stackexchange.com/>

MathPlayer's support for math continues to grow with MathPlayer 4. At the time of this paper, MathPlayer contained over 1,100 rules to provide speech text for different mathematical notations in addition to thousands of rules to speak various mathematical symbols. MathPlayer also supports speech and navigation for chemical formulas such as H<sub>2</sub>O (spoken as either "H 2 0" or "water"). Translations exist for 14 languages in addition to English: Chinese, Czech, Danish, Dutch, German, Greek, Spanish, Finnish, French, Icelandic, Italian, Japanese, Norwegian, and Swedish. MathPlayer's speech can be customized in several ways by users. Customization features include speech based on disability, expertise level (terse and more verbose forms), and subject area. Authors who use MathType can also customize the speech by either specifying exactly what should be spoken or by specifying a preference: for example to speak numeric fractions such as 21/30 as ordinals ["21 thirtieths"] or using "over" ("21 over 30").

MathPlayer 4 also includes some powerful navigation features that help users explore and understand larger expressions. It includes three modes of navigation, the ability to get an overview of the expression, the ability to set/read/move to place markers, and the ability to ask "where am I?".

## Creating accessible math

Depending on someone's needs, it may be important to create a large print document, an embossed document, or an online document. A common workflow in the United States is to either create the document in Microsoft Word or import it into Word and then convert or type the math into MathType's math format. Once in Word, it is relatively straightforward to get the output in different formats:

**Large Print**—choose large font sizes for the text and also format the math (using "Format Equations" in MathType's ribbon) to enlarge the math.

**Embossed Braille**—both Duxbury's Braille Translator (DBT)<sup>41</sup> and ViewPlus' Tiger Software Suite<sup>42</sup> convert Word documents to embossed Braille and convert MathType's math in them to a math Braille code.

**Online Documents**—MathType can convert Word documents to web pages via the "Export to MathPage" menu item in MathType's ribbon. These pages can be read by the AT software mentioned earlier. With MathPlayer 4's ability to speak, navigate, etc., math in Word documents, providing the unconverted Word document may be the most convenient way to distribute a digital version.

## Summary

As discussed, there are now many sites that supply accessible math and many AT solutions that can read it. There are a few solutions such as ChattyInfty<sup>43</sup> from the Infty group that allows for accessible WYSIWYG editing. It is very likely that the next few years will bring many more accessible editors and that math accessibility will no longer be difficult to achieve.

## Learning Points

- International web and eBook specifications make provision for a W3C standard for math: MathML.
- It is now possible to create and read accessible math equations using mainstream software, browsers and devices.
- Users now have access to increasingly customizable solutions, in which they can decide how and in which format they wish to read, hear or touch the different components that make up an equation.

<sup>41</sup> <http://www.duxburysystems.com/>

<sup>42</sup> <https://viewplus.com/product/tiger-software-suite/>

<sup>43</sup> <http://www.inftyproject.org/en/index.html>



## Making Complex Content Accessible

# From Bitmap Graphics to Fully Accessible Chemical Diagrams

**Diagrams are an important teaching tool in STEM subjects. Providing sophisticated recognition tools can make diagrams fully accessible for students with visual impairments, furthering their full inclusion into mainstream education.**



**By Volker Sorge, Senior Lecturer, School of Computer Science, University of Birmingham and Managing Director of Progressive Accessibility Solutions**

Dr. Volker Sorge heads the Scientific Document Analysis Groups at Birmingham University, working primarily on mathematical document analysis, diagram and handwriting recognition. Practical applications of his research include making scientific content accessible, for example, working as a Visiting Scientist with Google on math integration into ChromeVox and, most recently, by exploiting image recognition to generate accessible chemical diagrams with his startup company, Progressive Accessibility Solutions.

## Introduction

Visually impaired learners represent a sizeable minority of users of scientific material. For example, it is estimated that there are 25,000 visually impaired children and young adults in England and Wales who require specialist education support. More than 60% of this group are educated in mainstream schools and are often without specialist technical equipment, such as high definition magnification tools and Braille embossers.

The majority of these users rely on software-based assistive technology

such as screen readers and magnifiers, which are mainly geared towards handling textual information. However, teaching STEM subjects (i.e., Sciences, Technology, Engineering, and Mathematics) relies heavily on the use of informative and detailed diagrams. But since diagrams are usually given in standard bitmap image formats such as gif, png, and jpeg, they are effectively nothing more than rectangles of meaningless pixels that cannot be voiced by screen readers. Magnification tools also struggle with bitmaps since resolution does not increase proportionally with magnification, leading to a loss of image quality, which, in practice, renders most diagrams completely inaccessible to visually impaired users. Even when alternative text descriptions are available, they in no way compare with the richness of information provided by even relatively simple diagrams. It is generally not sufficient to describe STEM diagrams superficially, as students need to know precisely what a diagram depicts. Moreover, diagrams are often too complex to grasp from a single description but need to be explained giving first an overview of what is depicted before diving deeper into single components.

## Finding an automated solution to making chemical diagrams fully accessible

While there have been a number of approaches to make scientific and particularly chemical diagrams accessible, they generally require both authors and readers to use specialist software to create and read diagrams, which reduces their effectiveness in practice. To overcome this problem Progressive Access has designed a fully automated workflow that bridges the gap from images to accessible diagrams and no longer relies on authors to produce images in some special format or readers to familiarize themselves with a new bespoke tool<sup>44</sup>. It pairs the expertise of several years of research at the University of Birmingham on chemical diagram recognition in the context of image search in patent databases, with a six month commercial project on web diagram navigation.

Progressive Accessibility solution combines four independent computational

<sup>44</sup> <http://progressiveaccess.com/chemistry/index.php>

steps into a single software pipeline:

1. Image analysis recognizes molecule diagrams regardless of authoring style and image source.
2. Diagrams are faithfully reproduced in a Scalable Vector Graphics (SVG) format that is amenable to scalable display and interaction in a web browser.
3. Semantic enrichment computes detailed and precise information on the depicted chemical molecule and its components.
4. A rich navigation model on the SVG allows users to explore diagrams interactively on any ordinary web browser with speech output, synchronized highlighting and magnification.

### Image Analysis

Initially the bitmap image of a diagram is automatically analyzed using vectorization and image segmentation to extract a set of geometric primitives that compose a skeleton molecule. Primitives, for example, are lines, circles, characters, etc., together with their geometric location on the original image. This process is fully generic, that is, it is independent of the actual type of diagrams being analyzed but is only limited with respect to the type of geometric primitives being extracted. Subsequently, knowledge about molecule diagrams is used to distinguish bonds and atoms in the diagram. This recognition task is performed by a rule-based rewrite system, transforming the set of geometric primitives into a graph representation of the molecule diagram. The resulting graph structure is then translated into the Chemical Markup Language (CML), a standard chemical output format that specifies molecules in terms of XML elements for atoms and bonds.

### Annotated SVG Generation

This CML representation of a molecule can already serve as the basis to compute the corresponding diagram in SVG. Although, a number of solutions exist to do this, these are exclusively geared towards display rendering and discard all chemical information in the process. All the geometric components, lines and characters are set in a flat structure and lose all information about bonds or atoms in the process. To enable highlighting and magnification, a connection must be made between the geometric component of the SVG and the bonds and atoms in the input CML file. To do this, an SVG renderer has been developed. It uses SVG facilities to group elements together, to add attributes reflecting their chemical purpose and to connect them to their origins in CML.

### Semantic Enrichment

As the information provided by the standard CML only allows the construction of a simple graph representation conveying only trivial atom and bond information, the challenging step is to produce a semantically richer representation that allows one to describe both an overview of the diagram and the detail with scientific precision. This is achieved by computationally identifying the interesting components of a molecule, such as aromatic rings, carbon chains and functional groups, and combining them in an abstraction graph that consists of multiple layers reflecting the complexity of the molecule.

These layers correspond to different granular views of the diagram,

from the entire molecule via its major components to the atomic level. Descriptions for all components of the graph are automatically generated and relations between them computed by imposing an order dictated by chemical principles.

### Browser Front End

The annotated abstraction graph lends itself to a natural navigation model, which is realized via a simple browser front end. Standard JavaScript functionality is employed to import the annotated SVG and the enriched CML into a web browser. This allows one to effectively recreate a version of the abstraction graph inside the browser and to connect it to the corresponding components in the SVG. Some injected JavaScript code then enables the interactive exploration of diagrams. A user can in effect enter a diagram and interactively browse through its components on different levels and at different granularity (see Figure 2).

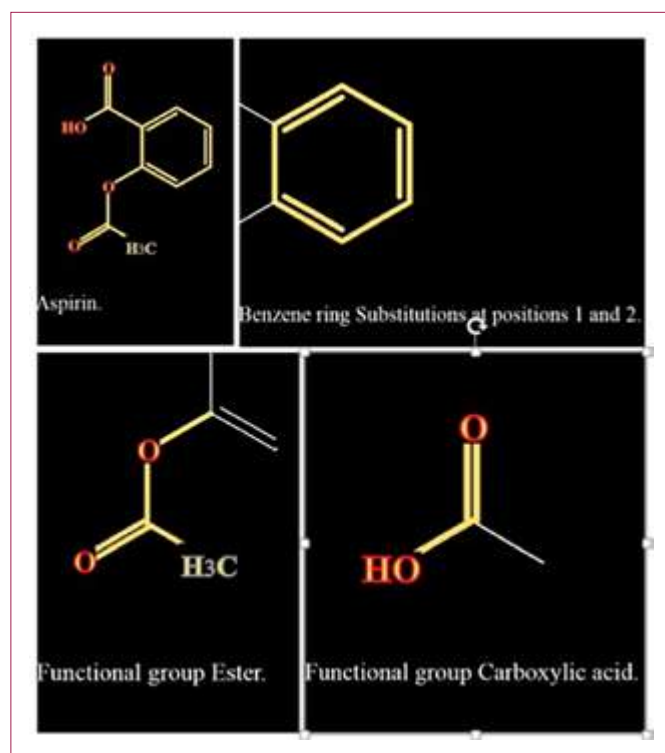


Figure 2: A chemical diagram of Aspirin shown at 4 different levels of detail with the section in focus highlighted

The components are presented to the reader as descriptions for aural rendering by a screen reader, for highlighting and optionally for magnifying specific parts of the molecule structure. None of these operations are browser, screen reader, and platform dependent; instead they rely on HTML5 and WAI-ARIA standards.



## Conclusion

This project has resulted in a solution for creating accessible diagrams from bitmap images to interactive diagrams that seamlessly integrate with assistive technology solutions already familiar to a reader. The software is commercially available as an independent system and individual components are currently being integrated into other recognition systems and support software for tactile graphics.

While recognition errors can be an issue, the advantage of starting with a bitmap image is that existing content can be made accessible retrospectively and without relying on authors to produce accessible diagrams. Bypassing the need for bespoke authoring and browsing tools also removes a significant hurdle to the production and the acceptance of accessible diagrams. Since the initial image analysis is generic, this solution has the potential to process diagrams from other STEM subjects like mathematics, physics and biology, by adding subject specific semantic enrichment. In the future this should enable greater access to scientific literature for visually impaired readers and significantly improve inclusive education.

### Learning Points

- Modern image analysis and semantic enrichment technology is strong enough to turn meaningless rectangles of pixels into fully accessible diagrams with detailed descriptions.
- Current web technology is already sufficient to provide a new level of learner independence for visually impaired students, although improved WAI-ARIA standards would still be beneficial.
- This approach is not restricted to chemistry but can be applied to diagrams in other STEM subjects.

## Accessible e-Learning & MOOCs

# Accessible e-Learning & MOOCs

The world of higher education has seen a dramatic step change in recent years as traditional learning environments are supplemented and, at times, rivalled by digital classrooms where large numbers of students are given access to free and interactive courses that can be accessed by anyone anywhere. But what are the implications for disabled users? Will online learning environments bring unprecedented opportunities for disabled students, or is there a risk of further exclusion? During a dedicated session, e-Accessibility specialist Jan Engelen put a selection of questions to a panel of three European specialists who are all involved in the production of accessible online platforms.



**By Jan Engelen, Stadius Centre for Dynamical Systems, Signal Processing and Data Analytics, Katholieke Universiteit Leuven (Belgium)**

Jan Engelen has a PhD in Electronic Engineering and is currently professor-emeritus at the Katholieke Universiteit Leuven in Belgium. His research focused on the usability and accessibility of ICT systems for groups with special requirements. He is and was involved in several e-Accessibility expert groups including EDeAN, DATSCG and several standardization initiatives such as SAGA and the Mandates 376 & 473. He has been active in many European research programs since the early 90s (Helios-Handynet, Telematics Applications Program, Copernicus Program, Framework 4, 5, 6 & 7 Research programs, Europe 2020). He is a founding member of LUCIDE, the Leuven University Centre for Interdisciplinary Research on Difference and Equality and the KU Leuven Working group on Digital Accessibility.

## Introduction

In recent years a new educational phenomenon has emerged with gusto: Massive Open Online Courses or MOOCs. While the Internet has been used to support learning for some time, MOOCs are specifically designed to be delivered online to large numbers of participants and can be accessed by anyone from anywhere providing they have an Internet connection. They are open to everyone without (tested) entry qualifications, and offer a complete learning experience online for free (although to obtain a certificate after the successful completion of a course, payment may sometimes be required). MOOCs are based on an educational model that advocates problem solving by students and steers away from the traditional lecture format.

Based on a similar concept, but more restricted in reach are Small Private Online Courses (SPOCs), which are geared towards a specific target group, have selective entry and involve fees<sup>45</sup>.

## Who is involved?

Most large universities today produce MOOCs. These are not usually geared towards existing students but rather aimed at providing an alternative learning experience for students from all over the world. More recently, however, universities such as Massachusetts Institute of Technology (MIT) have created MOOCs designed to deliver preparatory material for registered on campus students.

To organize and deliver their MOOCs, most universities rely on third party commercial software<sup>46</sup>. The drive from the 'traditional' world of open learning and education (i.e., the Open Universities) to open up education as much as possible has also resulted in federated MOOCs such as the OpenupEd pan-European initiative launched by EADTU (European Association of Distance Teaching Universities) in collaboration with the European Commission<sup>47</sup>.

<sup>45</sup> [https://en.wikipedia.org/wiki/Small\\_private\\_online\\_course](https://en.wikipedia.org/wiki/Small_private_online_course)

<sup>46</sup> An overview can be found on Wikipedia at: [https://en.wikipedia.org/wiki/Massive\\_open\\_online\\_course](https://en.wikipedia.org/wiki/Massive_open_online_course)

<sup>47</sup> <http://is.jrc.ec.europa.eu/pages/EAP/OpenEduMOOC.html>

## Expert Panel

The expert panel included three specialists involved in online learning environments:



**Sebastian Kelle** is a researcher in the fields of Accessible Media and Learning Technologies. He graduated from Freiburg University with a Master degree in Computer Science in 2006, and from Open University of the Netherlands with a PhD in Educational Technology in 2012.

Since 2008, he has been involved in several international EU-funded research projects, in the disciplines of Technology-Enhanced-Learning and Human-Computer Interaction. At the time of the Forum, he was based at Stuttgart's Media University where he worked as coordinating manager of the "MOOCs for Accessibility Partnership" project (MOOCAP). He is now based in Chicago.



**Susanna Laurin** is CEO at accessibility consultancy Funka and board member of the International Association of Accessibility Professionals (IAAP). She is also a fellow of the Swedish government's forum for usability and accessibility in ICT and an expert and advisor, both to the Swedish Standards Institute and Standards Norway. Susanna was responsible for the authorized translation of WCAG 2.0 into Swedish on behalf of W3C. At Funka, Susanna is involved in the project "A digital school for all", a specialized learning management system for children, teachers and parents with disabilities.



**Mathieu Nebra** created his business in 1999 at the age of 13 when he was trying to build his first website and realized that resources designed for beginners and available online were limited. He decided to create OpenClassrooms (or Le Site du Zéro as it was known at the time), an online platform offering tutorials on programming and development. OpenClassrooms is now Europe's leading MOOC platform. The community includes over 1 million members, and around 3 million users visit the platform each month to consult over 1,000 online courses in computer programming skills, but also in marketing, communications and business studies.

## Discussion

### Can MOOCs and online learning platforms complement more classic learning environments?

According to Mathieu Nebra this is perfectly possible. Many MOOC participants follow courses to get extra background information to support their studies ("flipped classrooms"). Students as young as 12-14 years old have registered to follow OpenClassrooms computer programming courses. MOOCs also prove popular with people looking for a job (or changing jobs). In France job seekers are entitled to follow certain MOOC courses completely free of charge.

### What advantages do MOOCs and online learning platforms provide over classic learning environments, particularly for students with an impairment?

Susanna Laurin stressed the fact that the online environment can, in principle, be very attractive for students with limited mobility and also for students with a reading impairment such as poor sight, dyslexia, or cognitive disabilities. But this is only the case if the learning environment is accessible. According to a 2010-2012 study undertaken by Funka for the European Commission, very little attention was given to accessibility at the time. The situation is now much better, due to a large extent to the availability of mobile and accessible systems such as tablet computers with built-in read out loud functionality.

### What are the key considerations for a school or university wishing to create an accessible online learning environment or wishing to adopt an existing system?

Sebastian Kelle suggested several items that should be taken into consideration. Given the significant amount of time needed to create a MOOC (good MOOCs are not simply recordings of traditional classroom courses but rather stand-alone resources), collaboration with multiple groups and universities is recommended. The next step, which involves finding an accessible platform, can also prove challenging, and building a bespoke system is sometimes necessary, as with the "MOOCs for Accessibility Partnership" project (MOOCAP). Finally a major challenge is to ensure that all downloadable material such as documents, videos and e-books are all provided in accessible formats.

### What are the principal technical and functional barriers preventing online learning environments from being fully accessible for disabled users today?

Mathieu Nebra created a MOOC on Java programming for a French IT company called Sopra Steria in which they solved most of the technical barriers to accessibility<sup>48</sup>.

- They made sure that the platform itself could be accessed on several systems and devices and that non-visual navigation was in place;
- All videos were subtitled;
- An audio description channel (describing what is happening on the screen) was integrated.

Feedback on the accessibility of the course is collected permanently. Not only students with impairment are pleased with the result; many other students welcome these improvements too<sup>49</sup>.

Organizational barriers also had to be tackled. Most of the teaching staff, for example, had no idea at first how to address students with a disability and had to be made aware that they could have quite a lot of students in their audience with special needs.

<sup>48</sup> <https://openclassrooms.com/courses/developpez-des-sites-web-avec-java-ee>

<sup>49</sup> It is well known that many MOOC students are not native speakers of the course language and therefore can benefit from subtitles too.

**As there are often many contributors to one MOOC, how is it possible to monitor and maintain the required level of accessibility?**

It is very important, according to Mathieu Nebra, to make sure that the platform is developed with accessibility in mind. It is then essential to ensure that permanent support is provided for MOOC collaborators, not only to support students with special needs but also to support teachers who often do not have first-hand experience of educational environments. A special MOOC designed to teach teachers about accessibility and how to reach students with an impairment, for example, was created in France for this purpose.

**Can standardisation improve the accessibility situation?**

Based on her experience with testing MOOCs at Funka, Susanna Laurin had to admit that very little standardization of MOOCs is in place. Given that these are Web-based resources, reference is often (but not always) made to the Web Content Accessibility Guidelines of the Web Access Initiative. Sebastian Kelle stressed that MOOC platforms have a very complex behavior (interaction with peers and teachers, tests, examinations) and cannot as such be considered to be simply a collection of static web pages. Also Mathieu Nebra judged that the MOOC field is moving very fast and that it is too early for standardization, which if it comes too early, can freeze the creative development work.

**What about the risk for further isolation for disabled users who learn remotely and have limited face-to-face interaction with their teachers and fellow students?**

According to Susanna Laurin, there are situations where face-to-face meetings are impossible or even sometimes not desirable (e.g. by students with psychological problems or mental disabilities who feel safe behind their computer but not in public). In general, youngsters tend to talk more often (and more freely) via internet channels (Twitter, Facebook), so face-to-face situations are not necessarily the most common form of interaction today.

## The way forward

MOOCs are still very young but statistics demonstrate that only a small percentage of registered students complete the course they signed up to or go as far as obtaining a certificate. Mathieu Nebra has studied this phenomenon<sup>50</sup> and believes this to be due to the following:

- Registering for a MOOC is too simple (especially if they are free) and the motivation to continue might not remain high enough over time;
- Some students need the structure offered by classical educational settings and/or are not sufficiently organized to follow an exclusively online program;
- Sometimes students are only interested in part of the course or in some of the course material.;
- Low success rates are rarely a reflection of the quality of the MOOC, but rather of the (often very specialized) content.

Nowadays most MOOCs are in English (in order to reach the widest possible audience) and MOOCs in other languages are growing at a slower rate. Sometimes universities explicitly focus on another major language to reach a specific audience<sup>51</sup>. This is the case, for example, with the École Polytechnique Fédérale in Lausanne (EPFL) which has developed MOOCs in French in order to reach a large African audience. The MOOC itself is supported by an extensive network of local assistants who have been appointed by the EPFL at many African universities to support (and motivate) the students.

To see a video of the panel discussion, please visit: [https://www.youtube.com/watch?v=zTtGGUmFLig&index=11&list=PL8Tu0\\_PVr4buqmuFjHqZkRKLruYxhhAcf](https://www.youtube.com/watch?v=zTtGGUmFLig&index=11&list=PL8Tu0_PVr4buqmuFjHqZkRKLruYxhhAcf)

<sup>50</sup> <https://youtu.be/0eVMkSggGCo> (in French)

<sup>51</sup> <http://moocs.epfl.ch/moocafrique>

## Developing Accessible Learning Experiences

# The French National Centre for Distance Learning's "E-Accessibility for Learning" program

As France's official provider of distance learning, the CNED has a duty to its staff, students, and the greater educational community to provide accessible learning environments and course materials. In a move to improve its digital presence and offer increasingly customizable services, the CNED, with financial support from the Fund for disabled workers in the public sector, has launched an ambitious e-Accessibility programme designed to create a wholly inclusive educational and vocational service.



**By Jean Millerat, Director of Innovation, Centre National d'Enseignement à Distance (CNED)**

Jean Millerat studied engineering at the Ecole Centrale in Lille. After creating his first start-up, he developed his skills in management and technology in the Information Systems Department of the building materials distribution group, Saint-Gobain. From this he joined Motorola as head of French operations in applied research on artificial intelligence and machine learning. He then moved on to create a digital business that encourages French IT services companies to offer *pro bono* services to charities, working in particular with disability and educational organisations. In 2012 he joined the National Centre for Distance Learning as director of innovation and launched the investment programme "E-Accessibility for Learning".

## The origins of the project and the key stakeholders

The CNED (*Centre national d'enseignement à distance*) is a public institution providing digital distance learning on behalf of the French Department of Education. As one of the largest continued education platforms in Europe and the French speaking world, it offers over 3000 learning modules as part of 500 courses to over 230,000 students enrolled each year.

The CNED is recognised as being one of France's most inclusive public sector employers, with over 10% of its staff classified as disabled, and 50% of its 2,200 strong workforce working from home as unable to teach in the classroom.

As the CNED steps up its digital presence, it believes that developing an understanding of the specific needs of disabled learners is necessary before customizable learning solutions can be developed and deployed.

The *Fonds pour l'Insertion Professionnelle des Personnes Handicapées dans la Fonction Publique* (fund for the professional integration of persons with disabilities in the public service sector) is the national organization responsible for collecting a financial contribution from employers to support disabled workers in the workplace. To advance digital accessibility in France and to increase access to employment remotely in France, the FIPHP decided to finance the CNED's "e-Accessibility for Learning" program from 2013 to 2018 to the tune of 6.95 million euros. The program was set up to create and deploy digital solutions designed to make learning and education more accessible to three distinct audiences:

1. CNED staff, including 1200 teachers working remotely on an adapted workstation;
2. CNED students, some of whom are disadvantaged through inaccessible learning environments;
3. Teachers and learners from other organizations who have difficulty accessing learning in their school, college or workplace.

The CNED chose to work with a service provider chosen for its digital accessibility expertise necessary for the effective implementation of the program<sup>52</sup>.

This paper sets out the different components of the plan for each of the three target audiences listed above.

## Creating an accessible working environment for CNED staff

### Computer equipment

To better integrate and equip members of staff working on adapted computers while taking into account the needs of the institution, 600 agents are now equipped with an adapted workstation (hardware and software), and benefit from training on how to use the equipment, a computer maintenance service, and hotline support. 400 further teachers will be equipped in 2016. The 1200 officers working on adapted workstations now have a @cned.fr email address which helps them feel better included in the institution.

### Raising awareness on professional inclusion

To facilitate the continued employment of its disabled staff, in 2015 and 2016 the CNED provided all staff members with dedicated online training covering disability awareness and the representations of disability, how to speak about disability among colleagues and steps that can be taken in the workplace to encourage inclusion. It will be made available in 2016 to all French-speaking employers.

### Training in digital teaching

CNED teachers are embracing the transformation of their profession through the adaptation of their workflows. The new digital educational environment requires a new approach to work and the development of new professional skills specific to their business. A significant in-house training program is underway to support teachers in this move to new working practices.

## Building an accessible learning environment for CNED students

From 2016, all new CNED courses will have a “reasoned” and “measured” level of accessibility. Many disabled students rely on assistive technologies (text-to-speech software, virtual keyboards, etc.) to access digital content. In order to be compatible with these technologies, course platforms and content must be built to international standards (WCAG, WAI-ARIA<sup>53</sup>) and fulfill the French government’s accessibility requirements (RGAA<sup>54</sup>). The level of accessibility of each new training module is assessed throughout the production process using specific tools such as the CNED Accessibility Guidelines. In 2015, over 200 instructional and editorial designers were trained on a new publishing workflow designed to produce accessible course materials. An internal network of accessibility experts and a management process have been rolled out to eight CNED production sites.

## Improving accessibility for primary and secondary schools, universities and professional training centres

### Schooling in French Sign Language (LSF)

For deaf students whose native language is French Sign Language, attending classes in French can put them at a significant educational disadvantage. The “e-Accessibility for Learning” program is looking for financial and instructional models to design and deliver classes remotely in LSF.

### Caring for Autism in the classroom

In France, the *Haute Autorité de Santé* (High Authority of Health) and the *Plan Autisme* (Autism Plan) recommend methods for caring for autistic students based on the “behavioural, developmental and educational” approach. Parents, teachers and classroom assistants have access to free self-study modules available on the CNED website since March 2014<sup>55</sup>. A series of online video courses and curated resources on how to adapt to autistic children in learning situations with the help of alternative communication methods such as Applied Behavioural Analysis, are provided alongside tips on how to build effective partnerships between teachers, parents and health professionals.

### Customised adaptation of educational material with Cned-Adapt

The layout used in textbooks is inaccessible to over 2% of students who suffer from cognitive disabilities such as dyslexia. The inability to comprehend these materials puts these students at a significant disadvantage and can lead to poor academic achievements. To address this issue, the CNED has set up a project called Cned-Adapt which aims to allow teachers to assemble or transform online educational content to produce customisable versions that can be adapted according to the abilities and requirements of each student: personalised fonts and line spacing; the colouring of specific syllables words or lines; simplified text-to-speech, etc. The aim is that teaching materials become usable and shareable in class or at home. Cned-Adapt is at present a web prototype licensed under the GNU AGPL licence. A pilot scheme involving thousands of French teachers is under discussion with the Ministry of Education and relevant charities.

### Personalized Schooling Program (PPS) and Custom Support Plan (PAP)

Each French disabled student benefits from a Personalized Schooling Program (PPS) and Custom Support Plan (PAP) which outline the support that will be provided throughout his or her schooling (human assistance, technical aids, adapted facilities, etc.). However, the process of drawing up these individual programs can prove challenging for families as it requires students, parents, teachers and health professionals to confer and agree on the appropriate approach. PPS or PAP are also difficult to implement as teachers rarely have sufficient training. The CNED aims to make more information and guidance on the PPS and PAP available via a digital service platform that will be launched in 2017.

<sup>52</sup> Alter Way ([www.alterway.fr](http://www.alterway.fr))

<sup>53</sup> The Web Content Accessibility Guidelines are published by the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C), the main international standards organization for the internet.

<sup>54</sup> The *Référentiel Général d'Accessibilité pour les Administrations* (RGAA) lists the statutory e-Accessibility guidelines for public sector websites in France

<sup>55</sup> <http://www.canalautisme.com/>



### Integrating young adults into the workplace

Rates of youth unemployment following graduation are even greater for disabled students. Employers (including the civil service) and young people must agree on their career paths, their needs and skills, and the appropriate solutions to mitigate or compensate for disability in the workplace. The CNED's "e-Accessibility for Learning" program aims to bring together recent graduates and employers and to speed up access to sustainable employment for young people, particularly those with disabilities. The first phase of the project is to create a wiki guide listing advice from community job center advisors, school careers advisors, and local outreach counsellors.

### Self-training in adapted and remedial education

To cater for the individual learning needs of each student with a disability, teachers need to have the appropriate training as differentiated instruction, individualization and remedial adaptation require specific skills and tools. The CNED program contributes to their professional training on these practices by working with the educational community to develop self-training modules on adapted teaching in mainstream schools.

### Self-training in digital accessibility

Digital content professionals, both from the public and private sector, need to have a grounding in digital accessibility. Part of this training can be provided remotely. After building training modules in 2014 and 2015 for use in house, the CNED hopes to share these with other professionals by publishing and opening them up to collaborative contribution in 2016 through Wikiversity.

## Conclusion

The CNED "e-Accessibility for Learning" program is ambitious in its objectives and in meeting its deliverables. The interim results are encouraging:

- 1100 CNED teachers with disabilities are better equipped and feel better included by their employer. They are also learning how to become more effective as online teachers.
- 200 CNED designers are now following a new workflow resulting in more accessible online courses.
- CNED-Adapt is publicly available as a software solution for students with cognitive impairments such as dyslexia.
- Over 2,000 families and teachers subscribe to Canal Autisme.

The CNED strives to provide an inclusive workplace for its own disabled members of staff, and to foster a greater take up of educational and vocational inclusion beyond the organization.

## Learning Points

- The CNED's "e-Accessibility for Learning" program is part of the organization's move to improve its digital presence and offer increasingly customizable services to its staff, to its users and to educational organizations.
- Disabled members of teaching staff account for 10% of the CNED's workforce. Making sure that these employees have access to appropriate training and computer equipment reinforces the CNED's role as the most inclusive public sector employer in France.
- To ensure that teaching materials are accessible to students, the CNED has developed a set of in-house Accessibility Guidelines based on the WCAG 2.0, WAI and RGAA standards. Content producers have been trained on how to implement these guidelines which are now integrated into existing content production workflows.
- A series of pilot projects and studies geared at providing accessibility support for educational institutions are underway. These all share a common goal of seeking to adapt the teaching environment to the individual needs of the student.

## Developing Accessible Learning Experiences

# Reliant on Readers, Stuck with Scribes or Independent with ICT? Can technology replace human support in examinations?

Over 10% of candidates sitting formal examinations in Scotland require some sort of support. In thousands of assessments, a practitioner reads the questions to the candidate and scribes their dictated answers. In 2008, the Scottish Qualifications Authority introduced digital question papers that can be read using text-to-speech software, with answer boxes for candidates to type responses. These have proved very successful and over half the schools in Scotland now use the papers. How do candidates, schools and the examination board benefit from these digital question papers?



**By Paul Nisbet, Senior Research Fellow, CALL Scotland, University of Edinburgh**

Paul Nisbet is Joint Coordinator of CALL (Communication, Access, Literacy and Learning) Scotland, the Scottish center of excellence in the application of ICT to support pupils with additional support needs. CALL is funded by the Scottish Government and through consultancies and contracts. Paul is a member of CALL's assessment and support service for pupils, with particular responsibility for access technology for pupils with physical disabilities, and for students with dyslexia or literacy difficulties. In addition to direct work with learners and staff in schools, Paul has driven a number of national developments. In 2010, Paul was awarded the University of Edinburgh Principal's Medal in recognition of his work.

## CALL Scotland

CALL (Communication, Access, Literacy and Learning) Scotland is based in the University of Edinburgh and is funded by the Scottish Government as a national center of excellence in the field of Assistive Technology in education<sup>56</sup>.

CALL works across Scotland to support all learners with disabilities or additional support needs who require technology to access the curriculum. The concept of 'additional support needs' focuses on needs rather than disability or impairment: what support does the learner require in order to successfully access the curriculum? It is not driven by impairment, but by need. CALL works with a wide range of learners who may have support needs in terms of seeing, reading, understanding, communicating, accessing technology, or writing and recording.

## Access to Scottish Examinations

The majority of students aged between 15 and 19 in Scotland sit formal examinations created by the Scottish Qualifications Authority (SQA)<sup>57</sup>.

Learners with disabilities or additional support needs may not be able to access the standard paper-based assessments, and so SQA has "Assessment Arrangements" to enable these candidates to demonstrate their abilities in SQA exams<sup>58</sup>.

Assessment arrangements can include, for example, extra time; the use of a reader or scribe; the use of technology; examinations printed on colored paper or in large print or in Braille; the use of signing; etc.

In 2014, 14,214 candidates requested the use of Assessment Arrangements (10.7% of the total number of candidates); arrangements were used in 43,344 examinations (6.4% of all examinations).

<sup>56</sup> CALL Scotland <http://www.callscotland.org.uk/Home/>

<sup>57</sup> Scottish Qualifications Authority <http://www.sqa.org.uk/>

<sup>58</sup> SQA Assessment Arrangements <http://www.sqa.org.uk/assessmentarrangements>



## Trials and pilots of Digital Question Papers

This project began in 2005. At that time, students could use computers and technology in examinations for writing and responding, but there were limited opportunities for candidates to use technology to read or access the question paper. Yet, the most common type of support (apart from extra time) in 2005, was a human reader – clearly indicating that there was a need for question papers in accessible formats. SQA already provided papers in Large Print, on colored paper, in different fonts and in Braille. Could digital papers with text-to-speech software provide an alternative to human readers? Could “write-on” digital papers provide an alternative to scribes?

### Choice of format

Pilot projects were undertaken with schools to investigate the features and requirements of digital question papers<sup>59</sup>. PDF met the specification. PDF is often regarded as an inaccessible format, so why was it chosen for the digital papers?

- PDF’s poor reputation in terms of accessibility often seems to be because PDF files can be very problematic for blind users who use screen reading software. However, PDF can be satisfactorily accessible for the majority of candidates who required assessment arrangements who are dyslexic or have got reading or writing difficulties. So a decision was taken to address the needs of sighted users by providing PDF versions of hard copy papers and to address the needs of blind users in a different way.
- The PDF papers are visually identical to the paper copies: the considerable advantage to this is that the process of designing and assessing papers is identical. Also, many candidates like to use both paper and digital formats together.
- Other factors were reliability, availability and cost for schools and users.
- Cost of production was low.
- Online assessment was not a viable option in 2005 because school Internet systems were not sufficiently reliable: PDF papers were well suited to delivery on CD.
- The choice PDF was a pragmatic solution to the problem of providing digital versions of paper-based question papers.

### Functionality

Learners with visual support needs can zoom in to magnify the text and images. The background color of the paper can be altered, as can the text and artwork colors. Learners with physical support needs can access the papers via keyboard, mouse or mouse alternative.

The PDF papers can be accessed on a wide variety of devices: computers, tablets and even mobile phones.

Initial investigation indicated that staff and candidates wished to be able to type on screen into papers that had a question-and-answer format. PDF ‘form fields’ offered this functionality. Almost any tool that generates text in the place of a standard keyboard can be used, including speech recognition, word prediction, on-screen keyboards; etc.

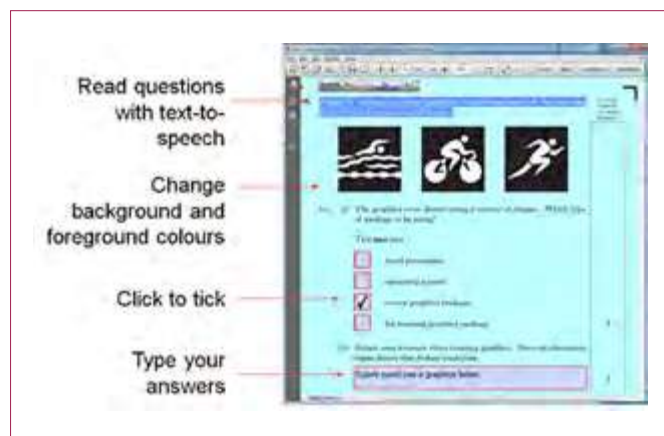


Figure 3: Screen grab of form fields in sample PDF examination. Annotations indicate which interactions can be actioned for fields included in example: a) read questions with text-to-speech, b) change background and foreground colors, c) click to tick, d) type your answers

### Enhancements

In 2005, the computer voices were relatively poor and either American or very ‘English’ accents. Pilot trials suggested that the voice quality was a barrier for many students<sup>60</sup>.

We therefore licensed a high quality Scottish computer voice (“Heather”) for Scottish schools in 2008, and funded the development of a male voice (“Stuart”) in 2011. Heather and Stuart were joined by “Ceitidh”, the world’s first Scottish Gaelic computer voice, in November 2015. Schools in Scotland can download these voices free of charge from CALL’s web site<sup>61</sup>.

The voices are licensed from CereProc, a world leader in speech synthesis, and a spin-off company from the University of Edinburgh.

Licensing the voices saves well over £2 million compared to the costs of schools buying the voices or buying text-to-speech software with high quality (English) voices.

But saving money is not the main motivation here: the chances of every school in Scotland buying high quality text-to-speech software is zero. By providing free voices, and free text-to-speech software, every computer in every school can have the necessary technology to access digital assessments.

<sup>59</sup> Nisbet, Paul (2012), “Accessible digital assessments for students with disabilities: specification, formats and implementation in schools”, *Journal of Assistive Technologies*, Vol. 6 Iss: 2 pp. 136 – 151. <http://dx.doi.org/10.1108/17549451211234984>

<sup>60</sup> Nisbet, P., Shearer, N. Balfour, F., Aitken, S. (2006) SQA Adapted Examination Papers in Digital Format: Feasibility Study 2005 – 2006: Final Report. Submitted to Scottish Qualifications Authority, October 2006. CALL Centre. <http://www.adapteddigitalexams.org.uk/Downloads/Reports/>

<sup>61</sup> <http://www.thescottishvoice.org.uk>

## Uptake since 2008

Digital papers in PDF were first offered in 2008 and the number of requests has steadily increased since then. By 2013, over half the schools in Scotland were using digital papers and requests for technology were greater than for readers or scribes<sup>62</sup>. The proportion of assessment arrangement requests that include technology has increased, whilst the percentage that include human support has declined.

## Limitations

Digital papers are not the answer for every candidate:

- The most common suggestion from staff is that all question papers should have the option of typing directly to the question paper on screen. This is because some examination papers require candidates to handwrite or type answers and responses into a separate answer booklet. On a computer candidates therefore use two files: the Digital Question Paper, and a Digital Answer booklet, which is more complex than a single file containing both questions and answers;
- Some questions are designed for paper and do not work well on screen. Questions that require the candidate to generate mathematical expressions, for example, are problematic because accessible equation editors are not readily available;
- The standard digital question papers are not sufficiently accessible for blind users using screen readers because some questions that make use of images (see below) would need to be modified to be accessible for blind users. In addition, the standard PDF files are not optimized for use with a screen reader.

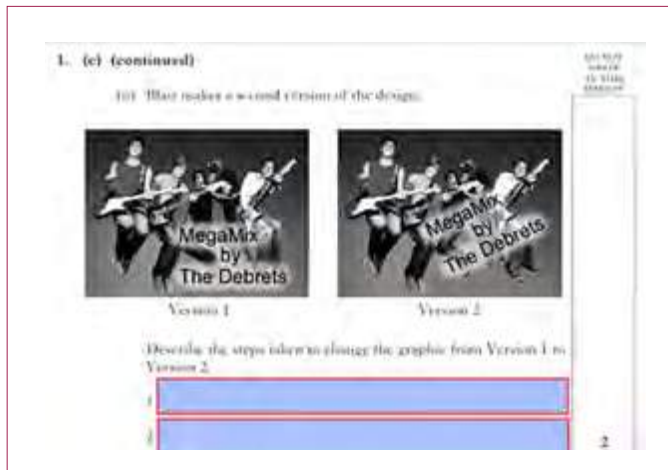


Figure 4: Example of question that is inaccessible to blind or partially sighted candidates. It is not possible to answer the question "Describe the steps taken to change the graphic from Version 1 to Version 2" without seeing the images where only the lay-out has been modified

## Conclusions

These limitations have not prevented schools and learners in Scotland from adopting the papers with enthusiasm. One of the reasons that schools favor digital papers is that fewer staff and fewer rooms are required than when using readers/scribes.

More importantly, digital papers offer a means for candidates to demonstrate their skills and abilities independently.

The PDF question papers are accessible to many candidates with disabilities who require support in examinations. These are digital versions of assessments that have been designed for delivery on paper – they have not been designed for digital medium – and so they are not suitable for every candidate or for every subject.

Nevertheless, evidence from schools and learners suggests that digital question papers in PDF format are viable alternatives to human readers and scribes.

## Learning Points

- In 2014, over 10% of Scottish candidates requested the use of "Assessment Arrangements" (extra time; the use of a reader or scribe; the use of technology; paper examinations printed on colored paper or in large print or in Braille; the use of signing; etc.).
- Despite its poor reputation in terms of accessibility, PDF can be satisfactorily accessible for students with dyslexia or difficulties with reading and writing (the majority of candidates).
- Students who rely on computer voices should not be penalized because the accent used is not their own.
- Collectively licensing voices saves the government a great deal of money and minimizes the costs associated with providing accessible exam papers.
- Since 2008 the number of requests for digital examination papers has steadily increased. By 2013 over half the schools in Scotland were using digital papers and requests for technology were greater than for readers or scribes.

<sup>62</sup> Nisbet, P.D. (2013) SQA Digital Papers 2012. Report for Scottish Qualifications Authority. May 2013. CALL Scotland. <http://www.adapteddigitalexams.org.uk/Downloads/Reports/>

## Co-curricular and Extra-curricular Learning

# Bridging the Gap: The Sign Language eLibrary of Finland

The Sign Language eLibrary of Finland was launched in 2014. Funded by Finland's Ministry of Education and Culture and managed by the Finnish Association of the Deaf, it provides signed video content for Finland's deaf community, but also serves as a rich resource for those interested in learning more about sign language and deaf culture. Firmly embedded in the Finnish library network, it provides both an access point and a voice for Finland's deaf community.



**By Riitta Vivolin-Karén, Sign Language eLibrary of Finland Producer, Finnish Association of the Deaf**

Riitta Vivolin-Karén has been involved in various projects focusing on sign language, lobbying, and network communication since 1982. She has a vast experience of working as a sign language teacher for deaf immigrants and hearing L2 learners and has been involved in the development of sign language tests (L1, L2). She has a Master of Arts degree in Sign Language from the University of Jyväskylä, and a Bachelor degree in Sign Language Interpretation from the Humak University of Applied Sciences.

## The Sign Language eLibrary of Finland

The Sign Language eLibrary of Finland is an online library open to all<sup>63</sup>. All materials in the library are in Finnish sign language and available free of charge regardless of place of residence. The library catalogue is made up of material produced specifically for the library, content produced in sign language available elsewhere on the internet, and material that library members have produced and submitted. The Finnish Association of the Deaf (FAD)<sup>64</sup> is both the administrator and the principal producer of library material and the project is funded by Finland's Ministry of Education and Culture.

At the time of its launch in 2014, the collection included around 240 videos in sign language, the majority either voiced over or subtitled into Finnish. At the end of 2015, there were over 400 videos on the library. The library aims to produce materials for a diverse public while considering the specific needs and wishes of its visitors. It is primarily geared towards the deaf and those who use sign language, but is also very useful to sign language teachers and students, and to anyone interested in sign language. It is an effective tool in helping to reduce possible prejudices and dispel the stereotypes that surround deaf persons.

The library initially focused its efforts on producing material for children and young adults, as these groups were poorly served in sign language material. To this end, the FAD paired up with the public broadcasting company of Finland to produce material for children, and with a group of young adults to produce materials for this second target group.

## Sign Language in Finland

As a result of the advocacy work of the Finnish Association of the Deaf, sign language was recognized as part of Finland's Constitution in 1995<sup>65</sup>. In 2015 the Finnish Parliament voted in a "Sign Language Act" protecting the rights of sign language and sign language users and clarifying their status as a language and cultural group<sup>66</sup>.

## Library Act

Finland has a population of about 5.5 million and over a thousand libraries, including both general municipal libraries as well as scientific and specialized libraries. The Library Act of Finland guarantees all citizens equal opportunities to develop civic skills, knowledge on different languages and cultures and lifelong learning. The principal objective of the Sign Language eLibrary is to support the implementation of this law in relation to the deaf population who require that materials be available in Finnish sign language.

<sup>63</sup> [www.viittomakielinenkirjasto.fi](http://www.viittomakielinenkirjasto.fi)

<sup>64</sup> The Finnish Association of the Deaf was founded in 1905. Its mission is to support and promote the status of sign language and the equality of deaf persons in Finland.

<sup>65</sup> Section 17 on the 'Right to one's language and culture' (see <http://www.finlex.fi/en/laki/kaannokset/1999/en19990731.pdf>)

<sup>66</sup> [http://www.eud.eu/videos.php?action=view&news\\_id=367](http://www.eud.eu/videos.php?action=view&news_id=367)

Before the Sign Language eLibrary came into existence, sign language materials were scarce in libraries. The FAD initially pitched the project to the Ministry of Education and Culture in 2007, and in 2013 funds from the state budget were allocated to setting up the library as part of their remit to promote accessibility to arts and culture in every possible way. During the startup phase (2013-2015), this amounted to 250 000 € per year, with a further 220 000 € per year thereafter to cover maintenance and production costs and a permanent staff of two.

## Objectives

The goal of the Sign Language eLibrary is to collect, produce, store and distribute materials in sign language and thus contribute to the preservation of deaf culture. The choice of materials takes the requirements set by the Library Act into account, for example the need for resources related to the development of civic skills.

Because a large part of the material has subtitles or voice-over, the library is an invaluable resource for studies in sign language and deaf culture and gives non-sign language users an opportunity to explore signed materials.

## User interface

The library interface was designed to be user friendly and require minimal knowledge of any written language so that it is accessible to children who cannot read and to immigrants and foreigners who are not conversant with Finland's official languages (Finnish or Swedish). User interfaces in sign language are not yet technically possible to build, but progress is being made in this domain. The library pages are both responsive and scalable and as such built to work on all devices.

## Cooperation

The Sign Language eLibrary has been warmly embraced and fully integrated into Finland's library network and many public library websites link to its catalogue. A cross-institution portal called the Finna-network<sup>67</sup> is currently under construction as part of a government project. Through this network, anyone will be able to access materials from all of Finland's libraries, archives and museums. The network is in discussion with the Sign Language eLibrary to join the project.

Public services and library services in Finland are increasingly available online. The Sign Language eLibrary is something of a pioneer in presenting not only the catalogue but the entire content of the library online for use without the need for membership or login.

The FAD and the Sign Language e-Library staff were invited to join a working group preparing accessibility guidelines for all Finnish libraries and were able to ensure that library users were well represented in these recommendations. The library has also produced video brochures in sign language about its own services and those of general library services that are available free of charge to all library visitors in Finland.

## The future

A specific task of the Sign Language eLibrary is to collect, publish and maintain the cultural and linguistic heritage of sign language and to ensure that it is preserved for future generations. In the startup phase of the project, efforts were focused on the production of original material in sign language. Future plans include translating Finnish literature that, aside from a few experiments, is rarely available in sign language.

The library strives to offer interesting and useful materials to its users. In addition to the subject areas outlined in the Library Law, it considers the wishes and needs expressed by library users when deciding which content to produce. In shaping its catalogue in this way, the library lays down the foundations for a wide and solid cooperation network involving different stakeholders. The Finnish Broadcasting Company has been closely involved in the production of children's programs and it hoped that they will continue to collaborate with the Library to produce programs for young people. For adults, in addition to civic and lifelong learning content, material for entertainment purposes will be developed. Meanwhile, the catalogue of content uploaded by deaf program makers will continue to grow as they are encouraged to contribute material via a secure publishing channel.

The future of the Sign Language eLibrary, like all libraries in Finland, is dependent on state funding. In order to safeguard funding, it is important to keep in regular contact with both Parliament and the Ministry of Education and Culture and report back on the activities and achievements of the library.

## Conclusion

The Library Law means that libraries have a statutory duty to make library materials accessible to all Finnish citizens. The passing of the Sign Language Act in 2015 has further strengthened the position of sign language and its users in Finnish legislation.

There are approximately 4 000 deaf persons living in Finland. In its first year of existence, the Sign Language eLibrary was visited by around 26 000 different users, and videos from the catalogue were viewed 143 000 times. The Sign Language eLibrary has attracted attention from the library sector both in Finland and abroad. In May 2015, the library was awarded a Jodi Award<sup>68</sup> for promoting access to cultural collections for disabled persons. The Finnish Association hopes to build on these achievements in the years to come.

<sup>67</sup> <https://www.finna.fi/>

<sup>68</sup> <http://jodiawards.org.uk/>

## Learning Points

- The Sign Language eLibrary of Finland is funded by Finland's Ministry of Education and Culture as part of its remit to provide access to library materials for all Finnish citizens in all official languages of Finland (which include Finnish Sign Language).
- The library is administered and maintained by the Finnish Association of the Deaf, and linked to from a network of Finnish libraries.
- Visitors are invited to take an active role in the growth of the library and mechanisms are in place to allow user-generated content to feed into the catalogue.
- In addition to providing access to library materials for deaf visitors, one of the key strengths of the resource is to provide access to sign language and deaf culture for the wider general public.

## Co-curricular and Extra-curricular Learning

# Building accessibility into mass digitization at the French National Library

**In order to create rich digital collections, the BnF has chosen to digitize its book collections using the EPUB format and in particular EPUB 3 which provides greater scope for integrating accessibility features. Two years down the line, how have digitization processes and workflows evolved to factor accessibility into native digital content production at minimal cost?**



**By Jean-Philippe Moreux,  
Conservation Department,  
Bibliothèque Nationale de France (BnF)**

Jean-Philippe Moreux is the BnF's in-house advisor on Optical Character Recognition (OCR) and editorial formats in the digitalization service of France's National Library. In this capacity he works

on all digitization projects at the BnF, including the production of digital books and research projects in which the national library participates. He is a member of ALTO<sup>69</sup> and METS<sup>70</sup> boards. An engineer by training, he was a project manager in an IT company, a scientific publisher and a consultant (editorial engineering, digital publishing) prior to joining the BnF.

## Introduction

Public libraries are investing more and more in the development of their digital reading offering. As keeper of the national collections, it is no surprise that the BnF has been committed to digitizing its collections since 1992. In 2011, the BnF decided to enhance its digital catalogue by moving over to the EPUB format. The great advantage of EPUB over formats typically offered by digital libraries (TXT, HTML or PDF) is that it is designed precisely to be used on nomadic and dedicated reading devices.

Between 2011 and 2013, mass digitization programs and the reprocessing of legacy digital content resulted in the production of EPUB 2 titles.

The current digitization program (2014-2017) builds on this experience as it moves the library's digital collections over to the EPUB 3 format, opening up the BnF digital collections to people with print disabilities. Today, the BnF produces around 1000 eBooks a year and its digital portal, gallica.bnf.fr, has around 3000 EPUBs available for download.

## Why Epub?

EPUB is a free and open standard published by the International Digital Publishing Forum. Since 2010, EPUB has become the de facto format for the distribution of digital books. Based on the technical formats of the Web, it offers guaranteed interoperability and conservation capabilities. Compared to PDF, it has the advantage of offering a more comfortable reading experience as a result of its text reflow operating mode, which allows the text to adapt to both the reader (font magnification) and the reading device (screen size).

In 2013, to meet its legal obligations regarding the accessibility of digital content, the BnF chose to use EPUB 3 for its many dedicated features<sup>71</sup>, including:

- enriched navigation tables;
- semantic tagging of content;
- description of the level of accessibility using ONIX metadata.

After assessment, the risk of EPUB 3 content being incompatible with EPUB 2 compliant reading devices was judged to be low. Furthermore, the BnF's EPUB 3 files do not use "risky" mechanisms such as fixed layout and JavaScript interactivity, or content such as multimedia. This assessment was grounded in user testing of accessible EPUB 3 samples on various EPUB 2 reading platforms. Since 2014, there has been general move from EPUB 2 to EPUB 3 compliancy in reading devices, though there are still some EPUB 2 devices on the market.

<sup>69</sup>. Analyzed Layout and Text Object Schema (see <http://www.loc.gov/standards/alto/about.php>)

<sup>70</sup>. Metadata and Encoding Transmission Standard (see <http://www.loc.gov/standards/mets/>)

<sup>71</sup>. EPUB 3 Accessibility Guidelines (<http://www.idpf.org/accessibility/guidelines>)



The BnF decided, alongside the production of EPUB 3, to generate DAISY XML files to facilitate the production of other accessible formats and to support the transition from DAISY to EPUB<sup>72</sup>. These DAISY XML files are based on the DTD DTBook 2005-3 standard<sup>73</sup>, but this choice may change with technical developments in the field (e.g. ZedAI<sup>74</sup>).

## Producing EPUB from the library collections

The implementation of this new format required detailed analysis and discussions between all teams involved in digitizing the library's collections.

### Document Selection

Due to the costs involved, not all digitized books can be converted into eBooks. The librarian, in the temporary role of a publisher, must make a selection according to agreed criteria. Reconciling a diverse corpus of publications, technical limitations imposed by the format and associated reading devices, and the lack of flexibility that comes hand in hand with a mass digitization program can prove extremely challenging.

Technical considerations, such as the quality and language of the scanned documents and the costs associated with processing them must also be taken into consideration.

### Content engineering

A "heritage EPUB" template capable of accommodating a wide variety of document types was defined along with eBook production guidelines<sup>75</sup> which list the rules for converting "classic" heritage digital documents (composed of a digital metadata and structure definition file, images and OCR files) into reflowable EPUB, covering:

- mapping of bibliographic metadata to the EPUB metadata;
- mapping of OCR "objects" to HTML markup;
- rules for creating several EPUB specific elements: cover, title page, table of contents, etc.

### Quality assurance

The automated quality controls designed to check digital documents produced by the BnF had to evolve to take the new format and the criteria outlined in the eBook production guidelines into account.

As a further safeguard, a team dedicated to EPUB quality control was set up to undertake:

- visual checking of EPUB samples on various reading devices and reading software;
- evaluation of the text quality.

### Archiving and long term conservation

EPUB files are controlled for quality before integration into SPAR<sup>76</sup>, the BnF long term digital preservation repository<sup>77</sup>.

### Distribution

eBooks are made available to users in the BnF digital library, Gallica.

### Production Costs

Improving text quality represents a significant cost: scanned content must be brought up to publishing standards (around 99.95% accuracy, depending on the production process).

It can be estimated that it costs up to three to four times more to process an eBook from a quality OCR scan and up to ten times more from a raw OCR scan.

Finally, limited budget means that the following content is not converted to EPUB:

- multilingual documents
- scientific content (formulae)
- indexes with hypertext links

## Producing accessible content

Moving from "classical" EPUB 2 to accessible EPUB 3 is accomplished using specific tasks and tools.

### Content engineering

Before implementation, a full analysis of the accessibility features offered by EPUB 3 was undertaken and considered in relation to the constraints of the BnF's mass digitization program. It was decided that the following features would be utilized:

- A new layer of logical structuring using HTML 5 markup and EPUB 3 semantic annotation (epub:type)
- Enriched navigation tables (page lists, landmarks)
- Markup of language at paragraph level

However, the following accessibility features were excluded:

- Alternative text for illustrations
- The markup of isolated words in a foreign language

The production of DAISY XML files follows a new set of digitization guidelines<sup>78</sup> which detail the mapping rules between EPUB 3 and DTBook 2005-3 content. It is worth noting that EPUB 3 and DTBook vocabularies are at times inconsistent and somewhat limited for certain document types such as theater scripts, poetry, and educational texts.

It is important to note that the corrected text is inserted in ALTO files (a dedicated OCR format generated alongside the EPUB 3, XML DTBook versions), thereby improving the overall quality of the Gallica text index.

<sup>72</sup> Matt Garrish. "DAISY to EPUB Migration" (<http://matt.garrish.ca/2014/01/daisy-to-epub-migration/>); Transition to Inclusive EPUB 3 Ecosystem (<http://www.daisy.org/ties>)

<sup>73</sup> DTBook was developed by the Daisy Consortium as an accessible file format similar to HTML, with special regard to the requirements of the visually impaired. It is defined with a DTD as part of the NISO standard Z39.86-2005.

<sup>74</sup> ZedAI is an XML-based Authoring and Interchange Framework.

<sup>75</sup> « Référentiel EPUB 3 », version 1 [http://www.bnf.fr/documents/ref\\_num\\_epub3.pdf](http://www.bnf.fr/documents/ref_num_epub3.pdf)

<sup>76</sup> Système de Préservation et d'Archivage Réparti.

<sup>77</sup> [http://www.bnf.fr/fr/professionnels/spar\\_systeme\\_preservation\\_numerique.html](http://www.bnf.fr/fr/professionnels/spar_systeme_preservation_numerique.html)  
Sophie Derrot, Jean-Philippe Moreux, Stéphane Reecht, et Clément Oury, "Preservation of eBooks: from digitized to born-digital", in Proceedings of the 11th International Conference on Digital Preservation (iPRES), Melbourne, Australia, 2014.

<sup>78</sup> « Référentiel DAISY », version 1 ([http://www.bnf.fr/documents/ref\\_num\\_daisy.pdf](http://www.bnf.fr/documents/ref_num_daisy.pdf))

## Quality Assurance

The BnF's automated control system has been updated to enable the management of both EPUB 2 and EPUB 3 format and their specific characteristics.

The Quality Assurance team have adapted their workflows to review EPUB 3 features, visually inspecting the navigation tables and new logical structuring markup.

DTBook files are verified using the DAISY Pipeline<sup>79</sup>, a cross-platform, open source framework provided by the Daisy Consortium for DTB-related document transformations. It provides a comprehensive solution for converting text documents into accessible formats for people with print disabilities.

## Distribution

Users searching for digital content can now search specifically for accessible eBooks, based on the presence (or absence) of an accessible EPUB 3 artefact.

## Production Costs

It can be estimated that the process to ensure digital files are accessible adds an additional 5% to the total cost of digitization. This is for the most part down to the extra engineering and operator work needed to apply a logical structure to content including the mark up of content elements at the macro level (foreword, acknowledgments, colophon, etc.) and micro level (epigraph, poem, etc.) and the identification of a book's structure (opening pages, body, appendices, etc.).

As DTBook files are generated by data mapping, there are no variable costs involved.

Finally, the average price per page is 0.4 € to 0.8 €, which includes OCR, text correction and the production of each eBook in three formats: EPUB 3, XML DTBook, and ALTO XML.

## Conclusion

With this latest phase of its digitization program, the BnF has proven that it is possible to produce accessible digital content natively with almost negligible additional costs. This content is perfectly readable on both generations of EPUB reading devices (although, of course, only EPUB 3 reading devices benefit from enhanced accessibility features).

Future digitization programs carried out by the BnF or its subsidiary BnF-Partenariats hope to build on the knowledge acquired in the field of accessible digital content. Most eBooks produced by these programs will therefore be accessible EPUB 3. This is the case for the ReLIRE/Indisponibles project<sup>80</sup> (2014-2024) which will digitize around 200 000 books.

## Learning Points

- Not only does EPUB 3 offer a more comfortable reading experience for all users, particularly on nomadic and dedicated reading devices, it offers a number of features that improve the accessibility of digital books, including enriched navigation and more granular semantic mark-up.
- The Quality assessment team at the BnF has adapted its workflow to incorporate a review of accessibility features as part of its standard quality control process.
- The BnF's digitization programme demonstrates that accessible digital content can be created natively with negligible additional costs (approximately 5% of the total cost of digitization).
- Accessibility will be built into all future digitization projects at the BnF.

<sup>79</sup>. DAISY Pipeline (<http://www.daisy.org/project/pipeline>)

<sup>80</sup>. ReLIRE project (<https://relire.bnf.fr/accueil/progressiveaccess.com/chemistry/index.php>)



# Conclusion

The world of education has seen a dramatic change in recent years as traditional instructional materials and learning environments are supplemented and, at times, rivalled by digital solutions.

However, despite the opportunities that digital solutions provide and the emergence of accessible and standardized formats and tools, we are yet to see a significant growth in accessible content. This is not so much a result of technological hurdles stalling the provision of accessible materials, but rather down to slow market adoption. Content producers and providers lack the basic training to be able to implement the necessary methodologies and technologies, and are failing to establish unified and seamless production chains for producing and packaging accessible content.

Collective efforts to inform, support and guide content providers and educational institutions in their provision of digital content will not only improve the accessibility of this content, but also incite tech vendors to write accessibility into their products and services at source. Building “born accessible” resources should not require publishers and educators to re-engineer their production systems, but simply to add a further step to their existing quality control procedures at a negligible cost.

Finally, efforts must be made to ensure that users are equipped to take full advantage of accessible learning environments. Without provision for this vital step in the information chain, people with disabilities will continue to be at risk of exclusion.

The articles in this white paper demonstrate that e-Accessibility is not just a question of technology, regulation, or market opportunity, but rather a fundamental component of an inclusive society in which each and every one of us is given an equal opportunity to succeed both individually and collectively.

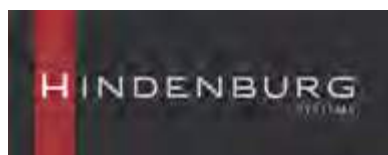
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