

Toward Accessible Online Learning for Visually Impaired and Blind Students

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Abstract –

The widespread adoption of blended and hybrid learning models, and the increased use of learning technologies, especially in recent years, have caused several challenges for students with disabilities as they are facing more complex barriers accessing and using digital educational tools and materials. Although such concerns are relatively not new in online education, their impacts on equity, inclusion, and access for people with disabilities have been deepened considerably during the covid-19 pandemic. This paper discusses challenges in online learning for blind and visually impaired students and highlights innovative inclusive technologies to empower them accessing online education.

Introduction

According to the World Health Organization WHO, there are globally at least 2.2 billion people with vision impairment (WHO, 2019). Basically, there are two broad categories of visual impairment, with distinct characteristics and needs: individuals with low vision and individuals with blindness. Vision impairments can affect a student's independence, mobility, and educational achievements, depending generally on the type, extent, and timing of vision loss. Similarly, the impact of vision impairment on learning varies depending on the nature and extent of vision loss. Students with vision impairment face challenges while reading and writing, and accessing technologies, sometimes even when using optical aids. In classic face to face models, inclusive classrooms are supposed to provide all students with adequate adjustments and reasonable accommodations, and assistive devices and technologies (e.g., screen-magnification, screen-reading software, Braille displays and notetakers, etc.) fitted to their needs to facilitate as much as possible their access to learning. Nevertheless, it's not likewise in case of online learning models, especially in times of emergency and crisis where educators and students are not prepared to deal with such extra challenges.

It was indeed the situation during the current Covid-19 pandemic that has created unforeseen challenges for educators and students (McKenzie, 2021). Most educational institutions worldwide have rushed to online learning models since the spring of 2020, and the focus on online education and technology seems to persist as a permanent trend in education in the future. In fact, according to the Horizon report 2021, several key technologies are expected to have more significant impacts on teaching and learning practices, namely, Artificial Intelligence, Blended and Hybrid course models, Learning Analytics, Microcredentialing, Open Educational Resources, and Quality online learning (Pelletier et al., 2021). On that premise, the ecosystem of ICTs in education needs to be strengthened toward embracing alternative and innovative inclusive models for educating

students with disabilities harnessing the technology trends.

Online learning challenges for visually impaired and blind students

Whilst online learning has created unprecedented access opportunities to education, especially in periods of crisis and pandemics, it is unfortunately considered as an additional burden impeding students with disabilities, visually impaired and blinds, getting access to quality online education on equal footing with their peers. Undoubtedly, the major challenge remains in the availability of accessible instructional online materials and services, and innovative assistive technology solutions. Indeed, this is what has been noticeably reported by the community since the rapid shift in many educational institutions to online learning, and the widespread adoption of blended and hybrid learning models. Most of visually impaired students have complained about unresolved accessibility issues hindering access to online learning, like incompatible materials with screen readers, late publishing of accessible course materials, using learning management systems, accessing textbooks, unavailability of affordable assistive devices including Braille and embossed diagrams, studying STEM subjects online and dealing particularly with graphs and equations, taking synchronous lectures on video conferencing platforms, taking tests and exams on online testing platforms, etc. (McKenzie, 2021). So, what are the possible avenues to address such shortcomings toward providing accessible online learning for students with visual impairments taking advantage of the key technology trends.

Accessible digital learning content

One of the main pillars in the online learning model is to provide quality digital learning content. Therefore, there is a need to make existing learning content accessible and to produce new content aligned with digital accessibility standards and guidelines. To this end, educators shall be aware of key approaches to create and remediate/convert easily and rapidly their education resources into accessible documents. Many apps and platforms offer accessibility checking tools that identify accessibility problems and provide suggestions to help making content accessible. Apart from known key accessibility features for people with low vision (like brightness and color, fonts, spacing for reading, elements' identification, complexity of the content, etc.), the most prominent consideration remains in the compatibility of the content with screen readers (e.g., JAWS, NVDA, Voice Over, Narrator, TalkBack, etc.). Therefore, a special attention should be given to content language, structure and linearization, and navigation. Furthermore, it is crucial to add Alt text and audio descriptions to graphic elements that can't be read or described automatically by screen readers like non-decorative images, tables, diagrams, videos, etc. It is also recommended when writing Alt text, to keep it short and descriptive, the added information should consider the element purpose and also the surrounding text on the page. Alternatively, it is possible to convert documents to accessible epub and/or simple web pages, and to creating standardized eLearning content (SCORM) using specific tools and suites for learning management systems. Obviously, creating a fully universally accessible learning content aligned to Universal Design for Learning UDL guidelines represents the best approach to be adopted from the beginning (Constantopedos et al., 2020). Besides the accessibility of

learning content, online learning platforms and applications must in turn enable students using accessibility features and ensure compatibility with assistive technologies, which allows digital educational content to be presented properly in multiple ways fitting better the needs and preferences of visually impaired students (e.g. enlarging and selecting fonts, adjusting color contrast and display preferences, adapting page content, simplifying interfaces, eliminating redundant details, using Keyboard navigation, etc.).

Accessible Open Educational Resources

As can be seen, all of the above approaches and strategies need time and competencies for educators and institutions to prepare and provide quality universally accessible learning content. Alternatively, to face such challenge, especially in times of emergency, accessible open educational resources have never been so urgently and broadly needed like these days (Huang et al., 2020) (Ben Brahim et al., 2017). Open Educational resources (OER) are "learning, teaching and research materials that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others" (UNESCO, 2019). Educators and students can avail OER as they encompass distinctive key characteristics, including the possibility of reusing and remixing. In the same vein, accessible open educational resources are aimed at breaking down content accessibility barriers and enabling freely shared accessible educational content meeting the needs of students with disabilities to increase their e-inclusion capabilities in educational settings (Zhang et al., 2020). In this context, as part of its endeavors to enabling equal opportunity for all to access education harnessing the power of inclusive ICT and the tremendous potential of OER, Mada has launched an accessible OER Hub on OER Commons, where accessible open educational resources are aggregated, curated, and managed through collections, and groups, and development tools. The Mada OER Hub will be of great interest to the community in Qatar and beyond to avail existing freely accessible digital content and to use it to support online learning for all including students with disabilities (Khribi & Al-Sinani, 2021).

AI-enhanced accessibility solutions

It goes without saying that the last decade has witnessed a tremendous rise of Artificial Intelligence AI being used in various fields all over the world. In the accessibility and education fields, advanced AI algorithms are being more widely used to enhance the learning experience for all providing solutions with better performance and capacity at a much lower price. Indeed, several AI based features and tools exist today and have been applied to accessibility domains (Dowdy, 2021). Some of the most visible examples of these AI features enhancing accessibility, especially for visually impaired and blind students, comprise the following (Caprara, 2019):

- Speech recognition allows to analyze video and audio content, and to identify speakers and recognize words they are saying through natural language processing algorithms. The technology is used for speech-to-text (STT) transcription, automatic captions, and translations (e.g., Microsoft AI for text description and captioning, translator, etc.), virtual assistants, and other speech user interfaces. Voice recognition

has also made it possible for the blinds to dictate and compose documents completely hands free (e.g., Dragon, dictation, Microsoft Word dictation, etc.).

- Voice Control allows to use voice access commands to control and interact with both devices and the digital content through AI natural language processing techniques (e.g., Google voice control in Android devices, Windows Cortana voice control, Amazon Alexa, etc.).
- Image Recognition and Automatic Alt Text, in case of non-existence of text descriptions for graphic elements provided by content authors, AI algorithms can examine images and generate dynamically alternative text that can be read by screen readers. (e.g., non-background image recognition in Microsoft Office).
- Text Processing & Adaptation, automatic adaptation techniques can enhance content accessibility for blind users. Adapting content by applying AI transformation techniques (e.g., link enrichment, image enrichment, and navigation enrichment) allow changing the structure of the content and enrich it (e.g., adjusting text based on reading level, adding element descriptions, etc.)

In addition to the features and examples stated above, many initiatives and endorsements programs are set to foster availing Artificial Intelligence technology to improve accessibility for the sake of persons with disabilities. The Endorsement Program of Mada (Al Thani et al., 2019) is designed to provide a launchpad for international/local established entities that already have ready-to-market ICT Accessibility and Assistive Technology solutions that require endorsement to access a broader market and specific institutions in Qatar and the Arab region. Mada has supported and endorsed several applications in the field of inclusive education, such as Class Quiz and Wonder Tree. In the same way, Microsoft has launched a specific program entitled AI for accessibility committed to harness AI capabilities to empowering persons with disabilities. In order to enhance accessibility in online education for visually impaired and blind students, many projects have been granted through Microsoft AI for accessibility program, such as I-Stem document accessibility portal, Improving braille literacy skills via gamification, and Automated generation of descriptions (Microsoft, 2020). I-Stem portal aims at remediating and enhancing accessibility of documents (including documents with complex layouts, STEM, etc.) by combining AI with human corrections through a dedicated remediation portal. Such automated remediation would help educators to get their materials aligned to the most prominent considerations of accessibility. I-Stem AI supports heavy math documents, and handles two-columns, headings, tables, and lists. The tool analyzes and converts to an accessible format that can be downloaded as text, mp3, docx or html (I-Stem, 2020). There are also other AI based tools for accessibility checking and remediation like Codemantra's accessibility Insight, which is an intelligent document processing platform that embraces machine learning to automate document accessibility production (Codemantra, 2021.), and AccessiBe which is a web automated accessibility remediation tool aiming at automatically detecting accessibility issues and remediating the content to some extent to comply with WCAG guidelines (W3C, 2018).

Braille innovations to support blind students

Braille is an alternative method for blind or deaf-blind people to read and write. Blind students are nowadays using a large segment of Braille electronic devices like refreshable Braille

display and notetakers. Blind students have faced several online learning challenges since the beginning of the Covid-19 pandemic as they were forced to deal with new online learning settings using virtual classroom tools and video calling platforms as well as various digital learning content mostly not accessible. Hopefully today things are getting better thanks to combined efforts of the community, educational institutions and technology providers that collaborated closely to make online learning more accessible for students with disabilities. In this context, Braille Institute of America centers e.g. have been providing online classes and services since schools closure. Visually impaired and blind students have been participating in live sessions with Braille Institute instructors by video or phone calls. Microsoft Teams platform is used for online classes, and students can participate and interact with their tutors and instructors using computer and mobile devices.

Additionally, advanced AI research is being conducted to computerize tutoring services for visually impaired and blind students using Braille. In this context, ObjectiveEd has obtained a grant from Microsoft's AI for Accessibility program, to develop Braille AI Tutor which is an innovative system aiming at enabling students to improve their braille literacy through a combination of speech recognition and engaging games (ObjectiveEd, 2021). The system is specifically designed to facilitate learning braille from home in a distance learning environment. ObjectEd can be included within online learning systems to be used by teachers and students. Braille AI Tutor is one of the technologies in the ObjectiveEd suite. A teacher creates his lesson using the ObjectiveEd web-dashboard, then Braille AI Tutor sends one word or sentence at a time to a refreshable braille display (Fig. 1), and the student speaks the sentence while reading the Braille words. Using Microsoft AI Speech Recognition, the student's speech is converted into text, and sent back to Braille AI Tutor to be compared with the original sentence to the text (Schulz, 2020).

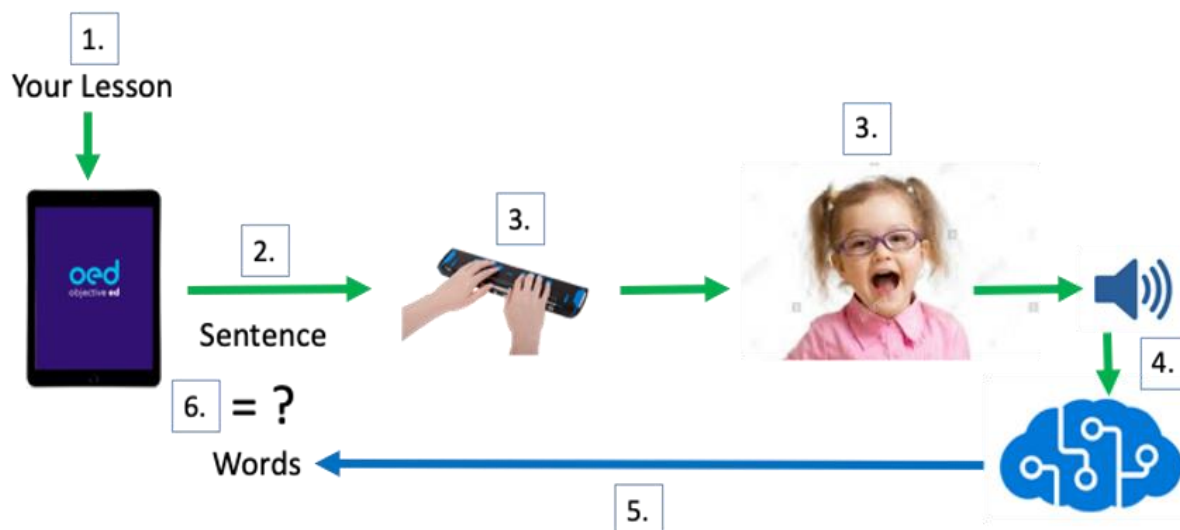


Figure 1. Braille AI Tutor

Equally important, in order to address the issue of limited number of braille cells displayed in a singular line in current Braille devices paired with computers, tablets, and smartphones, BLITAB Technology GmbH company created Blitab which is an Android tablet with 14 rows Braille display each with 23 6-dot braille cells (Fig. 2). The upper portion of Blitab is a multi-line braille display and the bottom portion has an Android screen (Brauner, 2017).

In the same way, PCT company developed Tactile Pro, a blind-only Tablet to print Braille and Braille drawings in real time, along with various applications such as editing documents, Internet, and games, as well as input and output devices for a Braille input and a Tactile Display. Tactile Edu is another product that is aimed at supporting Braille image education machine helping the visually impaired learn the braille and braille images by AI braille teacher bot's study guides (PCT, 2020).



Figure 2. Blitab: The Braille Tab

As studying STEM subjects is still challenging for students who are Braille readers, (Omone et al., 2021), many researchers endeavor to develop software and tools that can be used for accessing and transcribing text documents containing mathematical representations including equations, shapes, formulas, functions, etc. (Stone, 2020). In these circumstances. In this regard, a survey about the use of the Braille system in the Arab world conducted by Mada (El Ghouli et al., 2020) revealed a significant shortage of digital educational resources for the Arabic Braille system, especially in STEM subjects. Many problems were also reported regarding reading existing software capability to write and read in Arabic Braille. It is within this scope that Mada center launched the Unified Arabic Braille project, aiming at developing the Arabic Braille table used by assistive technology programs to input and showcase the braille method. As well as to develop the first 8-dot Arabic Braille computer table to support braille abbreviations in the fields of mathematics and science. Furthermore, Mada developed a web-portal containing a set of resources and lessons about Arabic Braille. The purpose of the portal is to provide accessible online learning content for blind and people who want to learn the Arabic Braille system.

Conclusion

Successful online learning experience for students with disabilities is mainly subject to the availability of appropriate technologies and accessibility, besides several other factors. The tremendous growth of technological capabilities and the widespread adoption of blended and hybrid learning models have opened the door to unprecedented learning opportunities for all students, including in principle those with disabilities. Nevertheless, the latter consideration remains contingent to what extent mainstream technologies in education are accessible and usable. This paper explored major barriers and difficulties impeding visually impaired and blind students to access online learning on equal footing with their peers and shed light on

potential solutions and avenues harnessing key technologies and accessibility to enable students getting the most out of educational technologies and better engaged and valuable learning experience.

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