Assistive e-Learning Software Modules to Aid Education Process of Students with Visual and Hearing Impairment: A Case Study in North Macedonia

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Abstract. This paper presents a technology4good initiative that integrates multiple breakthrough software modules with the aim to build a generic framework to aid the educational process for students with disabilities, such as, hearing and vision impairments, as well as various types of dyslexia. The purpose of the study is to apply various distinct researches among which the highlight is on the text-to-speech engine for the first time developed to support Macedonian language. Additionally, the framework integrates Macedonian sign language to guide the hearing impaired students through the contents of the educational framework. Also, there is a specially developed font (typeface) and color environment for students with specific reading difficulties (dyslexia). The methods that support the educational framework are developed by mix of social, special education and computer science experts. The methodology for developing the text-to-speech engine relies on the newest and most efficient principles in Machine Learning for Natural Language Processing - a Deep Learning approach. The framework has been tested on target group of students and the satisfaction has been measured by using the standard Likert scale.

Keywords: technology4good; educative framework; text-to-speech; deep learning; natural language processing; assistive technologies.

1 Introduction

A rapid take-up in the use of personal computers in 1970s and 1980s overlap the same time period, when society began to move towards providing equality for persons with disabilities [16]. Students with disabilities have been increasingly included in mainstream education classrooms and mainstream education teachers are often seeking ways to support students struggling with decoding and comprehension, especially as they access content area curricular materials. The evolution of the personal computer has had a significant impact on the provision of education for persons with disabilities. As legislators around the world created new disability and Information Technology policies, there are different legislation relating to Web Accessibility in some countries [6]. The Convention on the Rights of Persons with Disabilities, signed by over 150 countries, through Article 9 emphasizes the commitment to "promote access for persons with disabilities to new information and communication technologies and systems, including the Internet", and "promote the design, development, production and distribution of accessible information and communications technologies and systems at an early stage, so that these technologies and systems become accessible at minimum cost" [3]. Today, there is a wide variety of accessible technologies for individuals with different types and levels of disabilities such as mechanical switches, proximity sensors, adapted joysticks, voice recognition, head-trackers, eye-trackers, electromyography (EMG), elecotrooculography (EOG) and electroencephalography (EEG) wearable sensors, and there are many cost-effective technologies to help students access the curricula. But just because a technology is available does not mean that it enhances learning, or, is appropriate for every student. Selecting the best-fitting educational technology for the classroom is crucial to the success of the students who are using it [31]. In addition to the large number of different types of disability, the complex task of reading is one of the most commonly cited reasons for high dropout rates in schools through the world [2, 37]. Many high school students struggle with reading, especially reading comprehension, because of their slow rate and inaccurate decoding. In addition, many students lack sufficient content area vocabulary. This vocabulary gap widens over years, high performing students knowing about four times as many words as low-performing students in comparison to high performing first graders who know about twice as many words as low-performing students. Students who do not have the reading skills or access to improve their reading skills by high school may be more likely to dropout because they cannot keep up with coursework [37]. So, students with disabilities who struggle with grade-level content area texts, or those with specific reading and writing problems as well as blind students, can improve their reading comprehension by using technology to have texts read aloud [7].

Over the past ten years, rapid innovations in text-to-speech (TTS) technologies have created new and affordable ways to help students read print-based or digital texts that have no audio equivalents. TTS technologies provide students with the ability to hear virtually any text read aloud with a synthesized voice [35]. TTS software is one example of assistive technology (AT) that has become a more common tool for struggling readers in schools and colleges, and has been widely accepted as a form of accommodation for students with disabilities. It is important to look for accuracy in the conversion of text in reading materials, with tools like Optical Character Recognition (OCR), and the quality of the TTS voices. By presenting the words auditorily, the student can focus on the meaning of words instead of spending all their brain power trying to sound out the words. The TTS software analyzes the text using a system of phonics and other word-identification rules, and then reads the text aloud through voice synthesis. Users are provided a synchronized visual and auditory presentation of the text as they see the text on the computer screen and hear it spoken out [42]. Numerous commercial TTS software packages are available in various languages, however, prior to our latest research on the subject [26] which details are presented in the later sections, there was no appropriate TTS software able to reproduce the content of the screen in Macedonian language with a human-like voice, not the existing classic robot voice.

In this paper the focus is on the AT research realization in form of software modules that are integrated in e-Learning platform with the purpose to ease and make all the contents accessible to students with disabilities. The rest of the paper is organized as follows. The efficiency of the TTS systems in education improvement of students with disabilities is discussed in Section 2. The dyslexia, sign language and Macedonian TTS synthesizer research is provided in Section 3. Section 4 presents the architecture of the modules integrated in the e-Learning platform. The same modules are integrated by a developed mobile application which is described in Section 5. The satisfaction and efficiency is measured by specially chosen group of students and the results are presented in Section 6. Final Section 7 presents the conclusions and directions for future work.

2 Related Work

The effect of TTS on improving reading comprehension and education of students with disabilities has been widely studied in the last 30 years [27]. Speech synthesis as a category of software that converts text to artificial speech has a wide range of components that can aid in the reading process. Text-to-speech and related read aloud tools are being widely implemented in an attempt to assist reading comprehension skills in students with different types of disabilities or specific learning difficulties [41]. For students with reading disabilities, reading comprehension is often difficult [20], and the most current theories argue that one of the primary causes of reading disabilities is a struggle to decode written text. This has a direct negative effect on reading comprehension by decreasing word reading accuracy and speed. Inefficient decoding may also tax cognitive resources, leaving fewer resources available for comprehension. Presenting reading material orally in addition to a traditional paper presentation format removes the need to decode reading material, and therefore, has the potential to help students with reading disabilities better comprehend written texts. The results of the Wood's study [41] suggest that text-to-speech technologies may assist students with reading comprehension. Melisa Oberembt in [28] has made a review analysis of the twenty-eight peer-reviewed studies published between 2002 and 2019, elaborating the topic of the effects of the use of text-to-speech for students with disabilities. The reviewed research indicates that reading rate increased, while reading comprehension had mixed results, and writing skills did not significantly improve when TTS was used. Research also confirmed the social validity of TTS. Hebert and Murdock [15] investigated the acquisition of vocabulary for students with learning disabilities under three different situations: no speech, synthesized speech, and digitized speech. Three sixth-grade students with learning disabilities were given 25 words daily for 6 days using each of the treatments, using an alternating treatments design. Their results indicated that the use of digitized speech improved vocabulary acquisition over reading text without the assistance of digitized voice. Dawson, Venn, and Gunter [13] compared the reading fluency of students with behavioral disabilities. Three groups were identified: those using no reading model for assistance, students using the teacher to model reading one passage at a time, and students using TTS software that presented the text on the screen while it was read (without dynamic highlighting). Results were similar when researchers measured accuracy in the three conditions: the teacher model resulted in the highest means of accurately read words, while text-to-speech resulted in higher numbers of correctly read words than when students had no models. Monica C. Silió Barbetta [34] in their study confirmed that word prediction alone or in combination with text-to-speech had a positive effect on the narrative composition-writing skills of the fifth-grade Hispanic boys with specific learning disabilities. With text-to-speech alone, inconsequential results were observed. In [29] Parr in his research assess the attitude of the students toward TTS, determining the future of the TTS technology. He concluded that, when provided with TTS as part of a comprehensive reading approach, students naturally integrated it into the ongoing development of metacognitive strategies, student dialogue and collaboration, spontaneous reader response, and most importantly, self-efficacy and self-advocacy. Students agree that for many, TTS would be a nuisance, for some, a legitimate and equitable choice, and for a few, TTS, will be a lifelong tool.

3 Methods

This section explains the methods with which the software modules were developed and integrated in the e-learning platform. All the methods such as the Macedonian TTS system, the Macedonian sign language representation, and the Macedonian dyslexic font are originally developed for the e-learning platform needs and are considered pioneers for Macedonian language.

3.1 Macedonian Language TTS Synthesizer

In order to meet the needs of our software module, we needed to develop Macedonian TTS system from scratch and we relied on completely different methodology than any other trial before. Thus, we used the leverage of the Deep Learning approach and built a synthesizer that sounds natural and human-like, named MAKEDONKA [26]. Among the variety of Deep Learning-based methods, Deep Voice 3 was chosen to be most appropriate solution for the creation of Macedonian language TTS system, since it is able to synthesize more than 10M sentences per day [32], and thus is convenient for each day usage by the students who need its service in the process of learning. This ability is very important considering the purpose of its development - to help the students with visual impairment. This help means that sometimes it will be used only for navigation via the education platform, but also it could be used for "reading" entire books uploaded by the professors. To achieve single-speaker synthesis, approximately 20 hours of Macedonian high-quality speech audio dataset was created. The dataset has been preprocessed by following the example of the golden standard for training English language TTS systems - the LJSpeech dataset [18]. The total training time took 21 days and 16 hours. As a results, we achieved a model that produce intelligible human-like speech with no "robotic" components, which was found as very irritating in the previous attempts. The model has been evaluated on seven different sentences with certain specifics, covering variety of cases in the Macedonian language, such as: long / complex words in terms of pronunciation, compound words, comma somewhere in the sentence to check whether the model makes the appropriate pause when synthesizes the speech, sentences ending with fullstop, question mark and exclamation mark to check whether the model is able to change the intonation in the synthesized speech, tongue twisters, and tongue twisters containing words with multiple adjacent consonants. The quality of model was assessed by 15 distinct listeners who gave their subjective opinion on the quality of the synthesized speech. The obtained mean opinion score (MOS) for the ground truth and the selected TTS model, are 4.6234 and 3.9285, correspondingly. Thus, according to the MOS method [39, 33], the obtained value indicates a good quality audio, with no additional effort to understand the words, distinguishable sounds, not annoying pronunciation, preferred speed, and pleasant voice.

Creation of this model [26] is the first successful attempt for Macedonian language TTS synthesizer creation in the last 30 years. We are the first who built it and publish the model available to use as a module in any kind of software that needs its service. Further sections describe its usage as a module in education software to aid the learning process for students with visual impairment.

3.2 Macedonian Sign Language

Sign languages of deaf communities all around the globe are full-fledged human languages with full expressive power. Nevertheless, sign was once viewed as nothing more than a system of pictorial gestures without linguistic structure [14]. In the past, sign languages have been disputed in linguistic research and haven't been defined as real languages. This was due to the differences in sentence production in sign and spoken languages. Like spoken languages, sign languages have their own grammatical rules and linguistic structures. Sign languages do not follow the same grammatical patterns as spoken languages and there is a need for a substantially different conception of grammar [23]. This makes the task of translating between spoken and signed languages a complex problem, as it is not simply an exercise of mapping text to gestures word-by-word [38]. Sign languages emerge from and reflect the visual modality of their expression.

Spoken languages are primarily sequential, particularly when the role of word order is considered.

In the early days of linguistic research on sign languages, in the 1970s and 1980s, researchers noticed that sign languages have complex morphology. Further research showed that this morphological structure is simultaneous, in the sense that the different morphemes of a word are simultaneously superimposed on each other rather than being strung together, as those of spoken languages usually are [8]. From a linguistic perspective, the spoken/sign language comparison is easiest to perform within syntax. There are pervasive typological similarities between signed and spoken language in this domain [36]. Neidle et al. [1] point out that sign languages not only have a very liberal word order, but also, like some spoken languages, they do not have a hierarchic phraseological structure but use other principles (fluency articulation, economic saving by using articulation). Cecchetto and his colleagues [10] propose that sign languages have a modality-specific option for marking specific syntactic dependencies — i.e., non-manual marking—and therefore, that a different syntax is possible for sign languages.

Many researchers now agree that different types of non-manual markers contribute to sign languages in ways parallel to the contribution prosody makes for spoken languages [12]. For example, certain movements of the brows and head are used to mark yes/no questions, content questions, and topics, in many sign languages. Such markers may be the sign analog to intonational markers for such discourse structures in spoken languages. Generating sign language from spoken language is a complicated task that cannot be accomplished with a simple one-to-one mapping. Unlike spoken languages, sign languages employ multiple asynchronous channels (referred to as articulators in linguistics) to convey information. These channels include both the manual (i.e. upper body motion, hand shape and trajectory) and non-manual (i.e. facial expressions, mouthings, body posture) features.

Macedonian Sign Language, as a member of the large family of sign languages is a natural language [4] used by the Deaf community in Republic of North Macedonia, or, by approximately 6000 deaf individuals. Commercial applications for sign language primarily focus on sign gestures, by mapping sign to spoken language, typically providing a text transcription of the sequence of sign [38]. This is due to the misconception that deaf people are comfortable with reading spoken language and therefore do not require translation into sign language. However, there is no guarantee that someone whose first language is, for example, Macedonian Sign Language, is familiar with written Macedonian, as the two are completely separate languages. Using the expertise of deaf community members that understand both the Macedonian sign and written languages, we have developed a module that will ease the work on the learning platform as explained in Section 4.

3.3 Macedonian Dyslexic Font

An estimated 5–10 percent of the worldwide population is said to have dyslexia [22]. Persons with dyslexia have difficulties with recognizing printed words, have great difficulties 'sounding out' unfamiliar words, and read slowly. In European languages, which have more regular writing systems (transparent orthographies) than English, the main symptoms of dyslexia are poor reading fluency and spelling but the predictors of reading (and dyslexia) are the same, namely letter knowledge, phoneme awareness and rapid naming (RAN) skills [17]. Dyslexia occurs in all linguistic systems. Its prevalence is said to be significantly lower in linguistic populations in which the written language is more phonetically consistent, such as Spanish, Italian, Greek and Czech [30] and in these groups it manifests mainly as poor reading fluency. In North Macedonia, dyslexia is a widespread learning disability that impairs the ability to read fluently which in turn translates to a large number of students that have difficulties with their academic achievements.

In the past years, studies have been conducted with the purpose to define the usefulness of specially created typefaces (and subsequently fonts) for persons with dyslexia. In a research leaded by Bachman and Mengheri [9] it was concluded that reading becomes easier for dyslexics when changing the font from Times New Roman to EasyReading^{TM}. The results show a statistically relevant difference between the performances; the EasyReading^{TM} font resulted in a positive impact on reading fluency across all reading tests (excerpt, words, and non-words). A research conducted in the US, on the OpenDyslexic font on the other hand showed no improvement in reading rate or accuracy for individual students with dyslexia, as well as the group as a whole [40]. Recent research on a font named "Dyslexie", which is used in many primary schools in the Netherlands, concluded that the increase in size and space facilitates reading in children with reading difficulties, regardless of the font used [24]. In a study conducted by Masulli et al. [25], while reading texts in which the letters were larger and more spaced, the duration of eye fixations in dyslexic and in non-dyslexic children groups decreased, becoming similar to those reported in the non-dyslexic children group. This implies that large letter spacing between words could be employed in schools to help dyslexic children in order to ameliorate their reading performance.

Research conducted in the previous years shows that more stable orthographies have bigger use of specific typefaces than opaque orthographies and regardless of the typeface use, the reading fluency of persons with dyslexia benefits from increased spacing and font size. Leaded by this argument, a group of researchers from North Macedonia created the first Cyrillic font for persons with dyslexia in 2018. The font named DyslexicFZF, based on the Latin font Open Dyslexic, contains the main features owned by the larger number of fonts for persons with dyslexia. It is a Sans Serif font specifically produced for Macedonian alphabet letters, numerical and punctuation signs. The main feature of the font is the thickening of the base of each character, the increased size of the characters and the increased spacing. Having in mind that there is a highlighted ratio of the thicker and thinner parts, the font has a more prominent contrast [19]. A subsequent study was conducted in North Macedonia, with the purpose to explore the benefit of DyslexicFZF font. The results were in line with the above-mentioned research of the influence of specialized fonts in transparent ortographies. The respondents with dyslexia, read more fluently, made less mistakes and read a larger number of words with the DyslexicFZF font than with the Times New Roman font [5]. The development of the Macedoninan DyslexicFZF font was crucial for the successful creation of the dyslexia module which accompanied with palette of colors was integrated into the e-learning platform. Details can be found in the following Section 4.

4 Integration with e-Learning Platform

This section provides details of the software modules development as well as their integration into the e-learning platform. The platform is up and running and can be accessed on https://courses.fzf.ukim.edu.mk.

Figure 1 presents the home page of a user after login with his/her credentials. On the right side of the figure, are the three modules integrated into the Moodle e-learning platform: the Macedonian language synthesizer, the dyslexia module and the Macedonian sign language module. Each of them can be explicitly enabled by clicking on the corresponding button. For the dyslexia module, this button is presented in dyslexic font in order to be visible for the users. Once a module it enabled, it remains enabled until the user decides to disable it and return to a default mode.

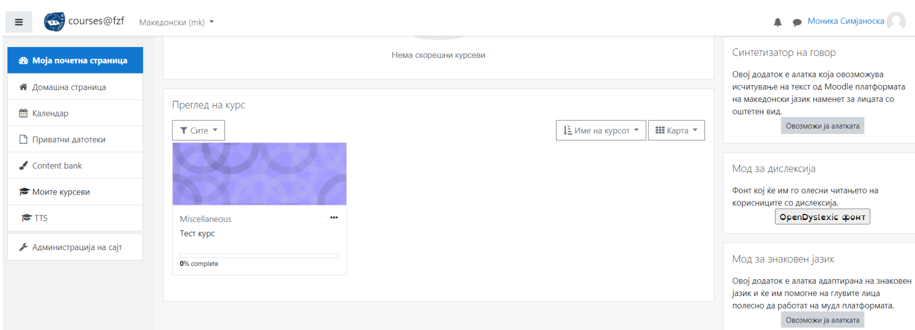

Fig. 1. Home page after login.

4.1 Visual Impairment Module

The visual impairment module refers to two target groups: those that have completely, or, partially lost their sight, and those that have difficulties reading the content of the e-learning platform because of any reason. In the previous Section 3 we explained the methodology used to develop MAKEDONKA - the first TTS synthesizer in Macedonian language. This intelligent synthesizer model resides as a service in the Cloud and serves the visual impairment module on request. Those requests are generated any time the mouse reaches a text label on the platform, meaning the page is not completely read as often is the case with other TTS systems implemented in some web pages. Instead, the synthesizer reads only the content at the paragraph pointed by the mouse. Even more, it is also able to describe the content even if it is given in a form of image, by reading the description of the image provided by the moderator which is not visible to the users. This option complies with the Web Content Accessibility Guidelines (WCAG) 2.1 standard [21] which defines the rules for representing the web content to persons with disabilities.

4.2 Hearing Impairment Module

Figure 2 presents the hearing impairment module when activated. When enabled, this module provides Macedonian sign language service to the student. Most of the important features of the platform were captured by an expert who perfectly understands both the Macedonian written and Macedonian sign language. Once the mouse points at some label, the video is started at the lower right corner of the screen, thus the textual content is not hidden from the student, but it is only additionally explained in sign language.

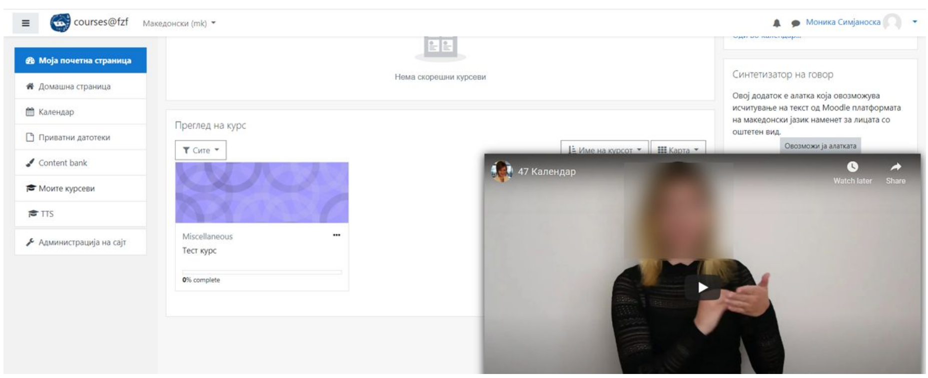

Fig. 2. Macedonian sign language module.

4.3 Dyslexia Module

Enabling the dyslexia module provides an interface as shown in Figure 3. The DyslexicFZF font developed by Karovska et al. [19] is accompanied with palette of colors that should additionally ease the reading of the students with dyslexia as there are many dyslexia typefaces. Changing the color changes the background of the paragraphs and thus provides more convenient contrast for the dyslexic students. The palette is selected by the experts in the field.

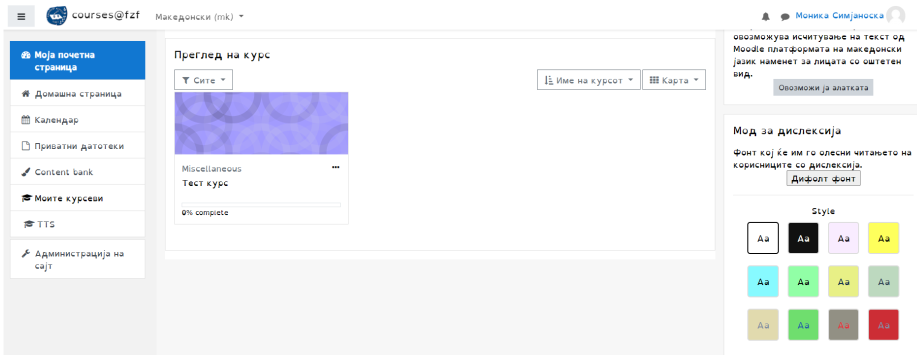

Fig. 3. Macedonian dyslexic font implementation.

5 Mobile application

In the literature review provided by Chelkowski et al. [11], the importance of the mobile devices for people with disabilities is clearly shown, especially for the visually impaired people. Considering the common keyboard and mouse inadequacy, we have decided to provide the same functionalities of the presented Moodle e-learning platform as custom-based mobile application that differs from the official Moodle application that exists on Google Play Store.

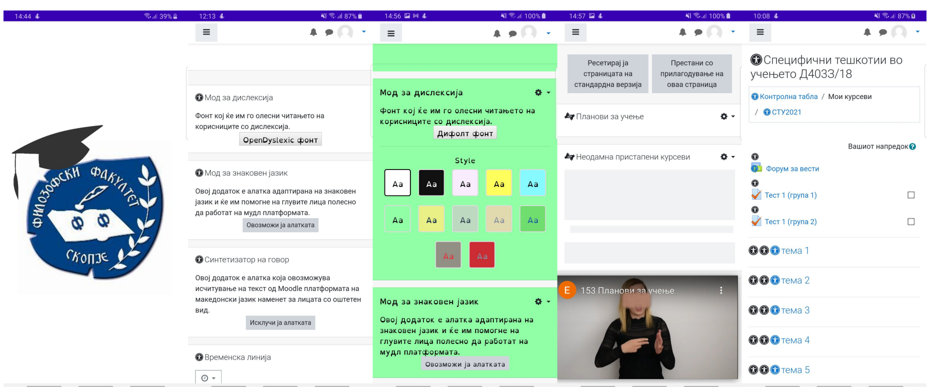

Fig. 4. Mobile application interface.

The interface of the application is shown on Figure 4. Starting from the welcome screen at the most left, the module for dyslexia, sign-language, and TTS can be seen. For the user to know the current mode, special icons are inserted next to the active labels at the corresponding mode. All the mouse functionalities are made to be touch-based at this application. The application is active and can be downloaded on Google Play Store by the name *Courses@FZF* at the link https://play.google.com/store/apps/details?id=mk.edu.ukim.fzf.moodlefzf.

6 Evaluation Results

To evaluate the students' attitude towards the e-learning platform and to confirm that software modules fulfill their needs, we conducted distinct surveys for each target group that contained 13 questions each. The answers describing their attitude and satisfaction were offered according to the Likert scale starting from 1 (Strongly disagree), 2 (Disagree), 3 (Undecided), 4 (Agree) and 5 (Strongly Agree). Tables 1, 2, and 3 present the results in terms of the percentage of students whose answer corresponds to each of the offered answers.

Table 1 presents the satisfaction of the students with visual impairment. As seen from the results, the students strongly agree on the appropriateness of the quality of the module and the overall e-learning platform, referred to as learning management system (LMS) in the surveys. The accessibility of the module, the activation, the settings, the notification, as well as the impact on the communication, are somewhat discussed by the students and it can be seen that there is some room for interface improvements.

Table 2 presents the satisfaction results from the group with hearing impairment. Compared to the results from the visually impaired group, in this case it can be seen that this group has no problem with activating the module and similar settings. Instead, what is more difficult to be understood is the format of the course content itself. This is understandable to some extent, since we have prior knowledge that even without visual impairment, this group needs more

Table 1. Students' TTS module evaluation according to Likert's scale

No.	Question	1	2	3	4	5
1	Do you find the accessible Moodle easy to navigate with the help of the TTS module?	0	0	0	50	50
2	Do you find appropriate the activation of the TTS module?	0	0	50	50	0
3	Do you find appropriate the voice of the TTS module?	0	0	0	100	0
4	Do you find appropriate the quality of the TTS module?	0	0	0	0	100
5	Do have easy access to the LMS and its content by using the TTS module?	0	0	0	0	100
6	Is the LMS easily understandable considering the adjustments made for your special needs?	0	0	0	50	50
7	Are you satisfied with the format of the course content being are posted on the LMS?	0	0	0	0	100
8	Are you satisfied with the LMS notification system?	0	0	50	0	50
9	Are you satisfied with the video-conferencing options of the LMS and are they adequate to your special needs?	0	0	0	0	100
10	Is the teaching staff responsive and communicating in a manner adequate to your special needs?	0	0	50	0	50
11	Has your productivity increased after the use of this LMS?	0	0	0	0	100
12	Have your digital skills been improved after the use of the LMS?	0	0	0	0	100
13	Has your communication with your non-disabled peers been improved through the use of this LMS?	0	0	50	50	0

Table 2. Students' Sign language module evaluation according to Likert's scale

No.	Question	1	2	3	4	5
1	Do you find the accessible Moodle easy to navigate with the help of the sign language module?	0	0	0	0	100
2	Do you find easy the activation of the sign language module?	0	0	0	0	100
3	Do you find the position of the videos to be user friendly and easy to follow?	0	0	0	0	100
4	Do you find there are enough videos to cover all the functionalities of the Moodle interface?	0	0	0	50	50
5	Is your access to the LMS and its content easier after implementing sign language module?	0	0	0	0	100
6	Is the LMS easily understandable considering the adjustments made for your special needs?	0	0	0	0	100
7	Are you satisfied with the format of the course content being are posted on the LMS?	0	0	50	50	0
8	Are you satisfied with the LMS notification system?	0	0	0	50	50
9	Are you satisfied with the video-conferencing options of the LMS and are they adequate to your special needs?	0	0	0	0	100
10	Is the teaching staff responsive and communicating in a manner adequate to your special needs?	0	0	50	0	50
11	Has your productivity increased after the use of this LMS?	0	0	0	0	100
12	Have your digital skills been improved after the use of the LMS?	0	0	0	0	100
13	Has your communication with your non-disabled peers been improved through the use of this LMS?	0	0	50	50	0

Table 3. Students' Dyslexic module evaluation according to Likert's scale

No.	Question	1	2	3	4	5
1	Do you find the accessible Moodle easy to navigate with the help of the dyslexic module activation?	0	0	0	0	100
2	Do you find appropriate the colors implemented as a background?	0	0	0	0	100
3	Do you find appropriate the implemented font?	0	0	0	0	100
4	Do you find the module activation button easy to spot?	0	0	0	0	100
5	Has the module made the access to the LMS and its content easier?	0	0	0	50	50
6	Is the LMS easily understandable considering the adjustments made for your special needs?	0	0	0	0	100
7	Are you satisfied with the format of the course content being are posted on the LMS	0	0	50	0	50
8	Are you satisfied with the LMS notification system?	0	0	0	0	100
9	Are you satisfied with the video-conferencing options of the LMS and are they adequate to your special needs?	0	0	0	0	100
10	Is the teaching staff responsive and communicating in a manner adequate to your special needs?	0	0	0	0	100
11	Has your productivity increased after the use of this LMS with dyslexic module implemented?	0	0	0	0	100
12	Have your digital skills been improved after the use of the LMS?	0	0	50	50	0
13	Has your communication with your non-disabled peers been improved through the use of this LMS?	0	0	100	0	0

descriptive approach to represent the contents and this should be taken into account for further improvements of the interface.

The satisfaction of the students with dyslexia is provided in Table 3. As expected, this group has no problems with any of the functionalities of the module, or, the platform in general. However, the format of the content still remains a problem for this group. What is clearly visible for all the groups is that this platform has not intrigued remarkable improvement in the communication with the other non-disabled peers. This might be as a consequence of inactivity of the other student considering the forum options of the platform. This, however, is a problem which is out of scope for this project and should be deeply analysed before appropriate advancements on the interface are made in order to achieve higher satisfaction.

7 Conclusion and Future Work

This paper presents a research that found its applicability in the assistive technologies field and is a real example of technology4good that should be followed by all software engineers. Making the content accessible for everyone should be considered a standard in any society.

The research presents the development and integration of three distinct modules in the popular Moodle e-learning platform. In order to encompass as much target groups, the modules are designed to aid the learning process of students with visual and hearing impairment. At the background of each module there is a comprehensive research including a deep learning approach to train high quality text-to-speech system. Also, experts are consulted for appropriate development of the sign-language and dyslexia modules.

Considering the fact that those target groups are more prone to using mobile phones, we also developed a mobile application that supports the usage of the modules considering the access constraints by the technology, i.e., everything is accessible on touch.

Each module is evaluated by a set of 13 questions reflecting the satisfaction of each target group. The analysis of the results provide some valuable conclusions on the students' perception of the usefulness of the modules and therefore, should be considered as directions for future improvement of the interface of the whole e-learning system in general.

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