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Inclusive MOOC – educational content for deaf people, a Portuguese proof of concept

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Abstract

The communication gap between deaf and non-deaf communities arises due to the use of distinct mother languages. A deaf student, who used to communicate in sign language, cannot read fluently materials written in spoken language. This fact causes serious difficulties to deaf students since most didactic materials in higher education are available exclusively in spoken languages. In this paper, we propose a pedagogical model to deliver educational materials in sign language aiming to provide deaf students the same conditions to succeed as the others, i.e., didactical materials available in one's mother language. Our approach involves the integration of automatic translation technology between spoken and sign language pairs into MOOCs. As a proof of concept, we used this methodology to design a course addressing digital literacy for schoolteachers. The evaluation of the inclusive MOOC and its underlying model reveals its potential, even though further improvements are required, especially regarding evaluation and usability features.

Keywords: educational content; inclusive MOOC, pedagogical model; assistive technology; automatic translator.

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1. Introduction

According to the last data of World Health Organization (WHO, 2018) there are about 466 million of people with hearing impairment in the world, and it predicts that hearing impaired conditions will rise to 630 million. When it comes to accessibility in education, deaf students face serious communication barriers which hinder their integration within the wider intellectual communities and limit their opportunities and chances to succeed.

The communication gap between deaf and non-deaf arises naturally since these two communities use distinct mother languages. Sign languages and spoken languages are distinct from each other in all their dimensions, from phonology and morphology to vocabulary and syntax. Spoken languages are linear; sign languages are visual and explore spatial dimensions. A deaf student, who used to communicate in sign language, cannot read fluently a spoken language, as much as people used to communicate in a spoken language cannot understand its sign counterpart. Digital information and most – not to say all – didactic materials are available in spoken languages, either in written or audio forms and naturally remain inaccessible to deaf students. Ziadat & Al Rahmneh (2020) research showed the educational challenges facing deaf people are "the need for sign language translator, lack of comprehends scientific subject, and lack of teachers' competencies and knowledge to teach properly".

Technological developments enable the emergence of tools and services to translate between spoken and sign languages; however, they are expensive and seldom available in education settings. The most common solutions rely on hiring interpretation services with expert sign language interpreters. These challenges, together with the fact that sign language natives are a minority, may force educational institutions to offer no solutions for deaf students thus blocking their integration in higher education. Nevertheless, the number of students with specific needs completing high school and enrolling in higher education has been rising therefore bringing to discussion the need for devising strategies of actual inclusiveness that enable access to the educational content and knowledge, improving communication and digital literacy.

Currently available technologies can be explored to develop digital content suited for the deaf, based on an inclusive learning approach, empowering deaf students with minimal computer expertise to acquire, enlarge and improve knowledge in a certain topic.

In this paper we propose a pedagogical model to deliver inclusive educational materials for the deaf, through Massive Online Open Courses bundled with sign language automatic translation technology. As a proof of concept, we describe a course addressing digital literacy for schoolteachers that was developed using our proposal.

This course was assessed by a group of users with regards to its inclusion features and its added value for deaf students. The results of this evaluation are encouraging and show positive impact.

At the remaining of this paper, we discuss the state-of-the-art of digital educational content available to the deaf, followed by the description of the inclusive MOOC we propose, highlighting the specific needs of the deaf. The process of translating digital learning material for deaf people from written or spoken Portuguese into sign languages is detailed. The specifications needed to structure the educational content for the deaf – underlying the two-way communication enabled by the automatic bidirectional translation – and how it can be used to promote integration and inclusive learning model (Escudeiro, et al., 2019) are also discussed. Moreover, an example of the development methodology when designing, structuring, and producing multilingual learning objects for the deaf, which may also be used by non-deaf individuals, is considered. This methodology, first designed to work with Brazilian Portuguese and the Brazilian sign language (Libras) – which differs from Portuguese sign Language (LGP) – also includes content in LGP. Finally, the evaluation approach to assess the quality of the inclusive MOOC is explained. Evaluation results are presented and discussed. In this evaluation process, the performance indicators from the Quantitative Evaluation Framework (QEF) (Escudeiro, & Bidarra, 2006) were applied, and two questionnaires for gathering the users' perceptions were produced.

1.1. Conceptual or Theoretical Framework

The first institutions offering courses on Portuguese sign language (LGP) were based in Setúbal. This has recently changed and, from 2005, higher education degrees concerning translation and interpretation of LGP started to be offered at the Polytechnic Institute of Coimbra and Polytechnic Institute of Porto. The existing offer comprises mainly undergraduate degrees in education and pedagogical sciences available at higher education institutions, focusing on sign language teaching and educating sign language translators, interpreters and teachers (Bento, Claudio & Urbano, 2014). According to Moraes et al. (2013), a significant part of the bibliography on technical subjects has been developed in Portuguese only, and deaf students rely on the exposition of the interpreted class, without being able to review the content and study materials produced in sign language.

The participation of sign language interpreters in the classroom results from a lack of adequate didactic materials and bilingual teachers. This contributes to the effective exclusion of deaf students in the academic community. Most interpreters do not have the same academic degree as the teacher and face difficulties with the concepts addressed in the classroom. This can directly affect the translation process from Portuguese into sign language, distorting understanding of the content by deaf students (Sousa & Silveira, 2011). In addition, schools and universities have neither the adequate physical infrastructure for this audience, nor teaching methods based on sign language and deaf culture (Galasso et al., 2018). It can thus be seen that public policies of inclusion, when poorly executed, result in ineffective deaf education as they do not allow access to learning through these students' first language (sign language).

1.2. Related Research

In recent years, there has been significant progress in the accessibility of education. According to Iniesto's recent work, very few authors provide an overview of the process of developing a MOOC having the question of accessibility as the centre of analysis (Iniesto et al., 2022).

Looking from a deaf perspective, we find that only the work of Gupta and Fatima (2016) proposes ideas towards the development of MOOCs for people with hearing disabilities. When it comes to the barriers imposed on deaf learners when accessing e-learning environments, McKeown and McKeown (2019) point out the learning management system (LMS), which are not usually designed in Sign Language, as well as barriers in the communication requirements and in course content and materials.

Finding other studies in e-learning systems with accessibility for deaf and hard of hearing has shown to be a complicated task. Some examples are worth describing here, such as the ones by Alcazar et al. (2016), Batanero et al. (2019), Esdras and Galasso (2020), and Batanero-Ochaita et al. (2021).

Alcazar et al. (2016) introduced a speech-to-visual approach e-learning system as a supplementary tool for teaching English in the Philippines. This system includes an English lesson management module, a speech recognition module, and an assessment module. They found that introducing a speech-to-visual approach e-learning system had great advantages when teaching deaf students because it enabled their comprehension of content and addressed their individual needs.

The study by Batanero et al. (2019) redesigned a Moodle platform to include accessible Learning Objects for deaf, deaf-blind, and blind engineering students. Their work was empirically tested with pre/post-test method, content before and after the adaptation of the learning platform, which resulted in an improvement of the academic performance of deaf and deaf-blind students by 46.25% and 87.5%, respectively. They concluded that accessible online education helps the learning improvement of students with different capabilities in telecommunications and computer engineering.

Esdras and Galasso (2020) designed the first bilingual virtual learning platform which includes learning tools such as Mental Map, Bilingual Forum, Personal Learning Environments, Digital Repository, among others.

Batanero-Ochaita et al. (2021) evaluate the accessibility and usability of a learning platform prototype and its content for deaf, deaf-blind, and blind. Their work found that all students had a positive response towards the adapted Moodle Learning Platform.

These are all examples within the field of digital accessibility for deaf students.

1.3. Purpose of the Study

Deaf students used to communicate daily using sign language, face serious difficulties to read content written in spoken language; this fact has a negative impact in their academic performance. Offering digital content in sign language will be of significant added value for deaf students who will then be able to study and learn using materials in their mother language, like the rest of the students. In this paper we propose a pedagogical model to deliver inclusive educational materials for the deaf, through Massive Online Open Courses bundled with sign language automatic translation technology. As a proof of concept, we describe a course addressing digital literacy for schoolteachers that was developed using our proposal.

2. Methods and Materials

The development of an inclusive MOOC involves multidisciplinary teams, so that an educational environment is built which comprises accessible, and innovative pedagogical settings.

The inclusive MOOC presented in this article was devised for the participation of deaf people. Portuguese-speaking countries together with Portuguese and Brazilian people all over the world are the target audience for the post-graduation degrees structured in these MOOCs.

Each MOOC follows a common model grounded in a specific pedagogical structure supported by adapted technology, devised to guarantee the post-graduation degrees' homogeneous features. Within this format, any content production must consider five key factors: structure, length, pedagogical design, content production and validation (Sousa, 2018; Queirós, 2018). Each course is a single homogeneous unit, of short duration, based on online learning, which complies with a set of specifications to ensure the MOOCs' coherence.

These specifications comprise: (1) the prerequisites and learning objectives; (2) the content supporting the lesson; (3) evaluation strategies; (4) the interaction model to be adopted including pedagogical tools for the deaf; and (5) an introductory welcoming video (Marques et al., 2017). Table 1 presents the specifications, scaffolding the structure of the course and the lessons within it. Continuous and active learning is enabled, with appealing, creative and up-to-date content, and the tasks to be accomplished according to each participant's knowledge and pace.

Table 1. Specifications to ensure coherence in the MOOCs

Elements in a course	Elements in a lesson
Promotional video	Title and subtitle
Theme	Lesson outline
Prerequisites	Learning objectives
Learning objectives	Presentation of appealing content
Course description	Questions to lead participants to apply/ demonstrate acquired skills and knowledge
Complementary material	Reference to the interaction model
Video lessons	Bibliography to be used
Lessons summary	Lesson conclusions and next lesson theme
Title and subtitle	Last lesson presents the evaluation strategy
Course promotional image (in every lesson)	
Trainer's biography	

The authors have embraced the challenge of applying the pedagogical model to inclusive and innovative MOOCs. The aim is to promote the inclusion in higher education of deaf individuals with the development of technical equipment, software, and strategies to extend the MOOC model to a multilingual environment, including Portuguese, Brazilian Portuguese, LGP and Libras.

All the professionals are involved in the planning and development to meet the objectives and enable a consistent development process, to produce a course suitable for deaf people (Figure 1).

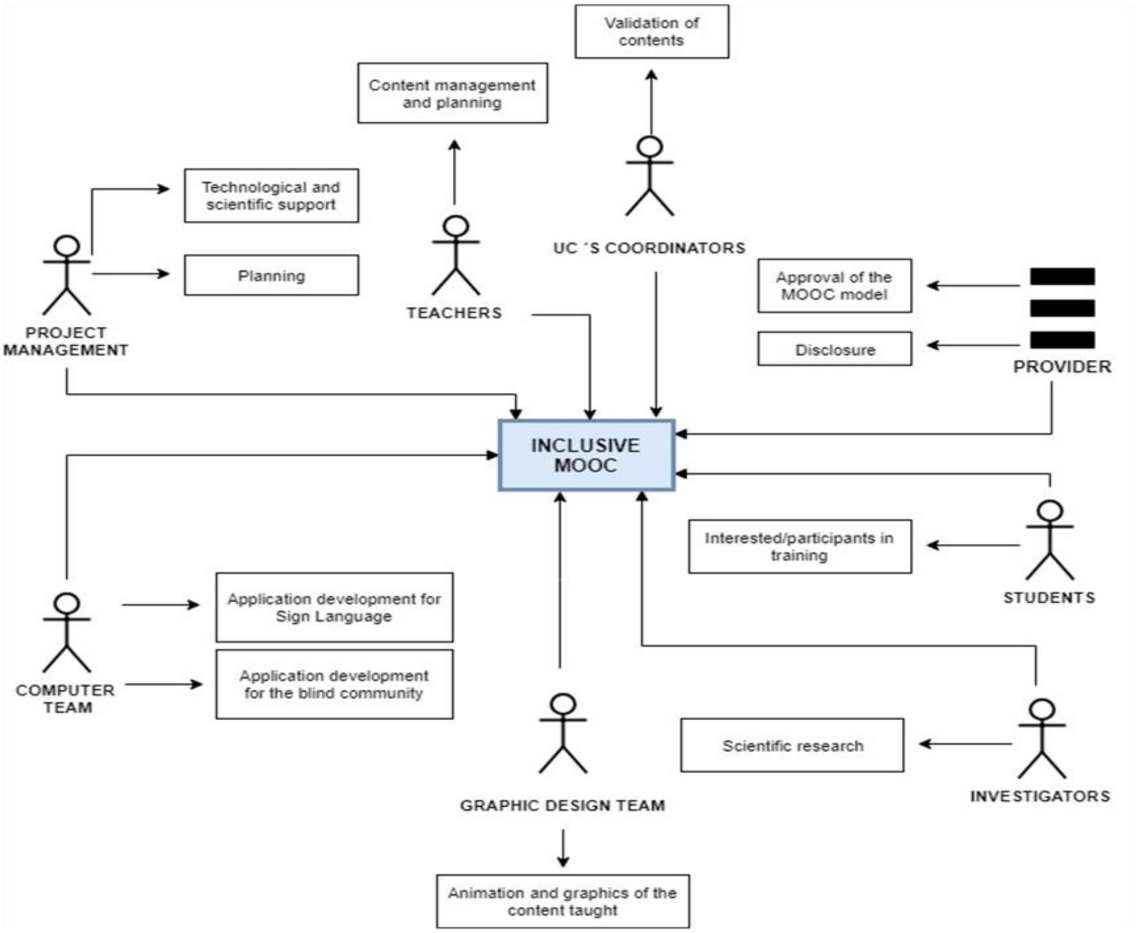

Figure 1. Stages in the inclusive MOOC approach and respective roles.

The sign language is made available through the VirtualSign technology that includes a 3D avatar who translates spoken to sign language.

The computer team is responsible for developing the sign language application – VirtualSign – (Escudeiro et al., 2013; Norberto et al., 2015) which enables the deaf to access the digital content and learning objectives, and likewise creating the sound environment, to allow the same digital content to be accessible for the non-deaf people.

VirtualSign is the bidirectional translator that translates LGP into written Portuguese, and the written text into LGP. The translation from spoken to sign language uses a 3D avatar to reproduce the animations mapping the corresponding text. This supports the intended interaction model for the MOOCs.

The MOOC design is the responsibility of the Graphic Design Team who employ storyboards to guide the lessons' recordings to avoid flaws in the task performance. The design team also oversees video recording, image editing, animations, and graphics integration, following the content input by the teacher.

The provider is responsible for disseminating the MOOCs through their network, and the "students" are the users of the final educational product. The teachers are responsible for planning and developing the content, including written texts, images, and videos. The UC Coordinators team validates lessons, with the design team overseeing any corrections and adjustments required to the audio. The research team ("investigators") is responsible for researching the specific needs of the deaf people to enable intuitive interaction. Finally, the project management team supervise the planning, while providing technological and scientific support for successful development.

2.1. Research Model

The MOOCs include an automatic translation system from text to sign and sign to text – based on the VirtualSign technology – to enable bilingual content and interaction.

Figure 2 details the pedagogical model, which integrates the content to be used by deaf students, and identifies each element: the digital content repository (DB), where the digital materials for a course are stored; the content experts (teachers), who may use diverse tools to provide the content (Word, PowerPoint, video, sound); the Kinect and the Sensor gloves, which enable the LGP specifications to be read by the computer; and the avatar, which allows the written text to be translated into sign language The educational content is translated automatically for both teachers and students without requiring them to master programming skills or be familiar with non-natural communication channels.

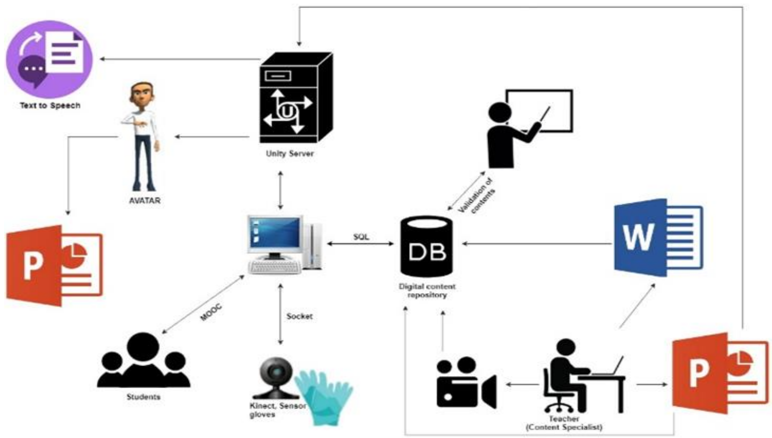

Figure 2. Design solution of the MOOC for the deaf

An audio add-on that converts text to speech was also included, aiming to integrate a simple interface empowering blind end-users to also benefit from the MOOCs. Although this is not core to the current work, this feature is a proof of concept that we are also interested to evaluate.

The MOOC must be clear and user-friendly for all deaf students. The participants are provided with an environment that enables them to interact with the content and succeed in accomplishing the tasks. The architecture of the sign language components is outlined in the next section.

2.1.1. Sign language translation component

It is widely known that deaf people rely on visual and spatial representations. to communicate while non-deaf are used to linear languages. These differences require distinct ways of communication for each group. The Assistive Communication for Education (ACE) architecture (Escudeiro et al., 2018), shown in Figure 3, matches these two distinct communication settings especially in educational scenarios, by using a model that considers the specificities of both the deaf and the non-deaf.

Figure 3 shows the two main modules that perform the steps needed in the translation process. The text recognition module converts the written text into signs, which are animated by a 3D avatar. The second module translates the sign language into text. In this process, two devices are used: the Kinect for motion recognition and the data gloves for the recognition of static hand configurations.

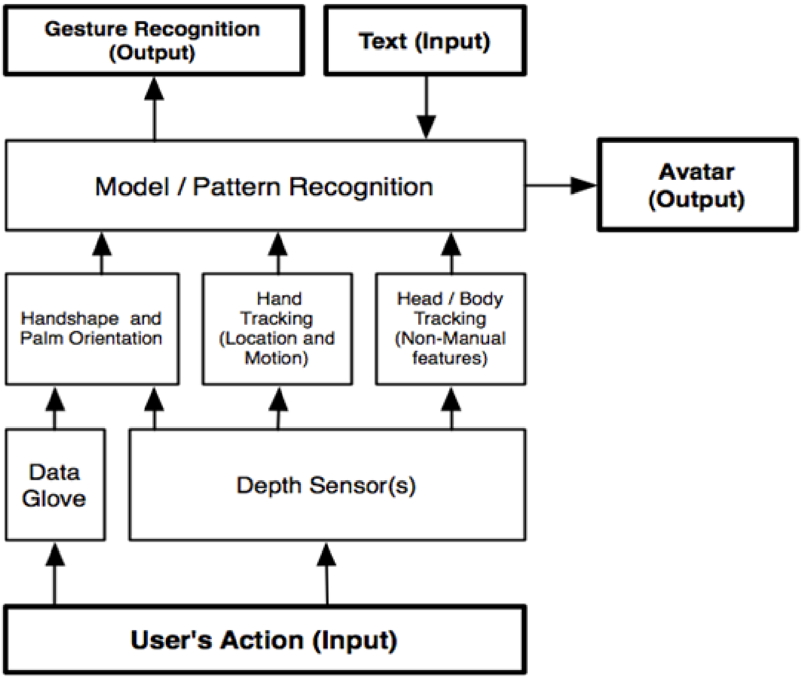

Figure 3. Translator architecture.

2.2. Participants

The evaluation of the inclusive MOOC was performed using the Quantitative Evaluation Framework (QEF). The study was conducted with a sample of twenty-three users, including 8 deaf respondents and non-deaf students (Table 2).

Table 2. Participants in the study

Group	Number of students	Age range
Dead students	8	18-30
Non-deaf students	15	18-30

The participants were required to provide their education level so that it was possible to infer the results on the content quality (Figure 4).

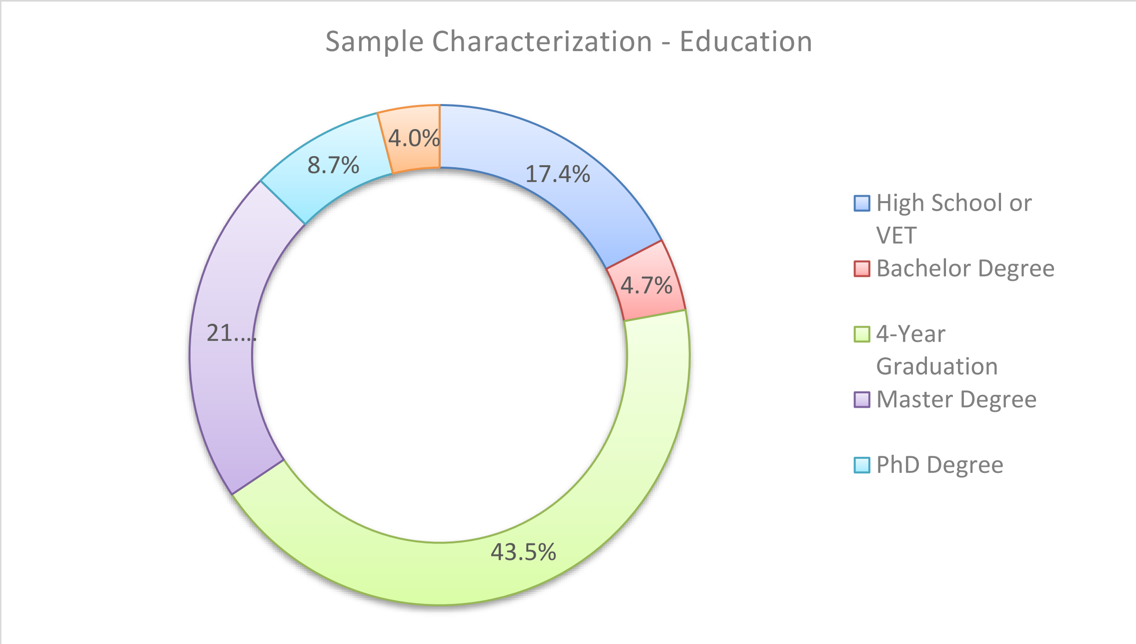

Figure 4. Respondents' characterization concerning the education level.

2.3. Data Collection Tools

The assessment procedure was implemented in two stages aiming to test the efficiency of the proposed architecture and the effectiveness of the MOOC content, its usability and accessibility features. We have used questionnaires to collect end-user feedback and generate the inputs required by QEF.

Our goal was to find out how the proposed model might enhance access to educational digital content, and whether factors in the performance indicators facilitated or limited its effectiveness.

2.4. Data Collection Process

We have been applying QEF to assess the quality of educational software products during their development cycle for the last 30 years. QEF has proved to assure consistency and coherence throughout assessment procedure that compute product quality and its evolution during the product development cycle. It enabled to assess the compliance of the proposed MOOC to the needs of the deaf students. Blind students were also involved in this process aiming to grasp the adequacy of the course for this group, although we are aware that the blind-oriented features of the MOOC are still at an early stage of development.

QEF uses performance indicators based on the standard ISO 9126 and SCORM, that provide a quantitative representation of product quality in an orthogonal space (Escudeiro & Bidarra, 2006; Escudeiro et al., 2017). For educational software products, we are using three dimensions: pedagogical, ergonomic, and management (Table 3).

Table 3. Quantitative Evaluation Framework (QEF).

Dimensions	Factors	Requirements
Pedagogical	Learning	Contents must be hierarchically and sequentially planned
		Contents must be divided into several knowledge stages, always starting in the least complex stage
		Contents, the course unit core, must reflect the best scientific or pedagogical evidence available concerning the subjects to be handled, and must be internally coherent, i.e., the considered subjects must be clearly linked and interconnected
		In each lesson/video class the interaction with the participant/attendee must be considered by including content-related questions directly addressed to the participant/attendee
		A course unit must provide constructive feedback
		A course unit must be prepared for participants with different profiles/disabilities
	Evaluation	A course unit must provide problems to be solved in a short period of time
		The activities proposed in the course unit must consider the participants’ collaborative work skills
		The course unit must propose critical reflections about its contents and developed assignments
		The course unit must allow the participants to choose their path while attending it
		The course unit must promote interactions and foster teamwork
		The Special Education course units (deaf and blind) comprising specific scientific and pedagogical contents must be validated by experts in these fields
Ergonomic	Usability	The participant must be able to start and conclude each lesson when he/she wishes it
		The course unit provide help through complementary material
		The lesson’s complementary material must be of easy and intuitive access
		The course units must consider a uniform help pattern
		The course unit must have various audios available, compliable with the participant’s needs (including the blind participants)
		The course unit must allow the participant to configure the audio
		The deaf must have access to the digital content by means of an automatic bidirectional translator which translates the Portuguese written language into the Sign Language
		The system must have an avatar to foster the interaction with the deaf participants

		A help button must be available for the deaf/hearing impaired
		A help button must be made available for blind/visually impaired
		The lesson must use of visual resources such as images and icons, to help transmitting the content better
		The lesson must consider human perception, i.e., must be prepared for the diverse participants' physical abilities/capabilities (deaf/blind)
		The course must enable the participant to receive feedback in a forum
	Video/Audio	The course is supported in digital video classes
		Video class must have 8 to 10 minutes-length, corresponding to each lesson
		Each course unit must have a brief introduction to the lessons
		In the video edition, the use of images, graphics and animations must be specifically prepared for the blind/visually impaired by a detailed audio description
		The video must include captions
		The audio is recorded in Portuguese
		The whole text is presented in linear and concise form
		The text included is written in Portuguese
	Text	The lesson title must be clear, objective, and appropriate to the content
		The content must be written following the Portuguese spelling agreement
		Whenever references are used, these must be included in the bibliography
Management	Content Management	Contents are created by team of certified experts in the field of knowledge
		There is a previous and appropriate content planning to assure the course homogenous features
		Content must be validated by the course unit's responsible teacher
		Contents addressing the blind/visually impaired must be validated by experts in the field
		Contents addressing the deaf/hearing impaired must be validated by experts in the field
	Adaptability	The course is adapted to be attended by the deaf/hearing impaired by integrating the 3D avatar
		The course is adapted to be attended by the blind/visually impaired by audio analysis and processing

Each one of these dimensions impacts the performance of the final product (Escudeiro & Escudeiro, 2012). QEF is grounded on a quality scenario that must be designed for every product.

2.4.1. QEF performance indicators

The Pedagogical dimension determines the interrelationship between the subject, the participant, the object and the technological instrument. The evaluation verifies which technological procedures are valid for the educational objectives (Bloom et al., 1956; Bloom, Madaus & Hastings, 1981; Eisner, 2000; Krathwohl et al., 1964). The pedagogical dimension aggregates two factors: learning and evaluation.

The Ergonomic dimension handles the scientific knowledge (Falcão & Soares, 2011; Fialho, 2018; Wisner, 1987), ensuring the conditions that directly affect a learning scenario in its technical, ergonomic, and social features. The ergonomic dimension aggregates three factors: usability, video/audio, and text.

The Management dimension reflects the quality from the functional and implementation points of view. This dimension aggregates two factors: adaptability and content management.

QEF computes the quality of a product based on the Euclidean distance between the real product, and a hypothetical ideal product. The coordinates of the real product is a weighted average of the values of the corresponding factors. The value of each factor is a weighted average of the percentage of fulfilment of the product features that contribute to the factor. The percentage of fulfilment of each feature is assessed using appropriate techniques for each measure, such as questionnaires or direct input from specific sensors. The quality of the product perceived at each evaluation is inversely proportional to the distance between the coordinates of the real product and the ideal product.

2.5. Data Analysis

The QEF results for each one of the dimensions under analysis are presented in Figures 5, 6 and 7, corresponding to the Pedagogical domain, the Ergonomic domain and the Management domain. These results aggregate the inputs provided by twenty-nine users including 6 blind users, 8 deaf users and 15 users with no sight or hearing impairment. These users were also asked to answer evaluation questionnaires that will be discussed in the sections following Section 3.3.

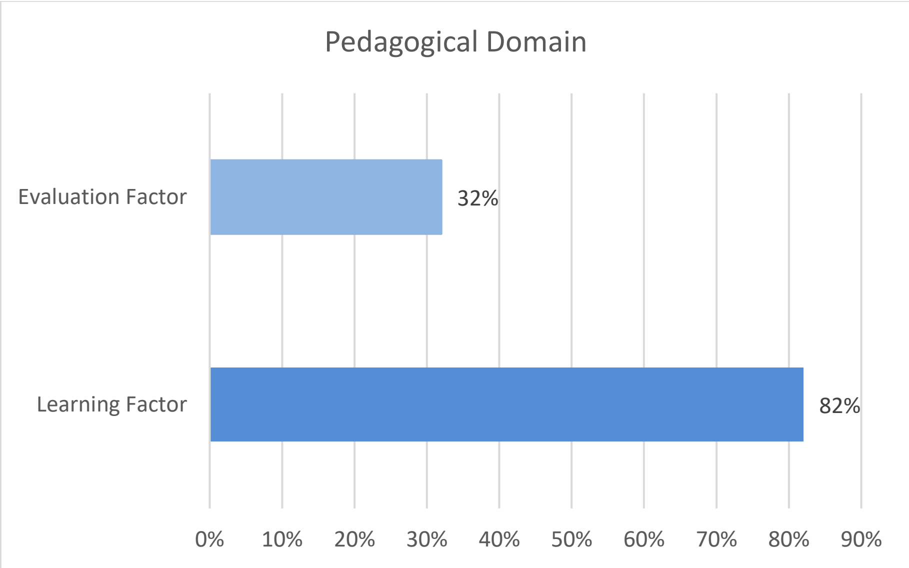

Figure 5. Results of the factors in QEF's pedagogical domain.

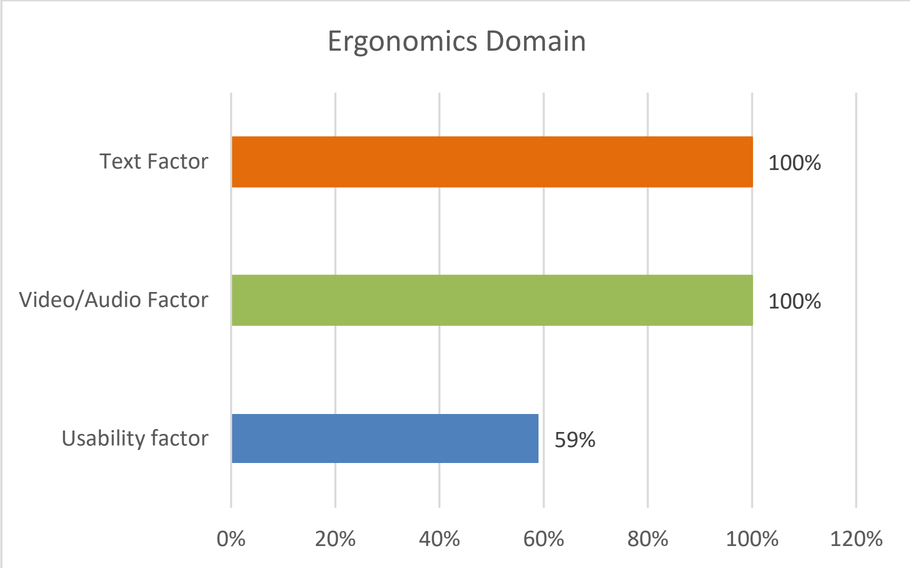

Figure 6. Results of the factors in QEF's ergonomic domain.

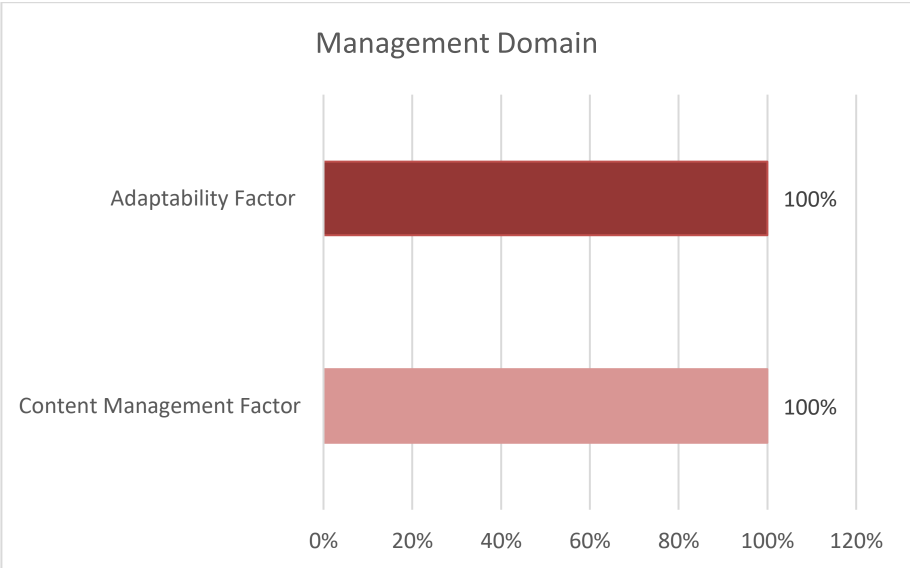

Figure 7. Results of the factors in QEF's management domain.

The evaluation of the learning factor in the pedagogical domain was 82 per cent, while the evaluation factor quality results were 32 per cent (Figure 5).

As to the ergonomic domain, the evaluation results on the three factors – usability, video/audio integration, and text integration – reached 100 per cent (Figure 6).

In the management domain, both the content management and the adaptability factors pointed to 100 per cent (Figure 7).

2.5.1. Testing user satisfaction

The MOOC prototype was tested with a sample of twenty-three users including 8 deaf respondents and 15 non-deaf (Figure 8, 9). Two different questionnaires were prepared using a five-point Likert Scale (Russell and Cohn, 2012) to measure the users' satisfaction. One of these questionnaires focused on deaf users and the other on blind users. The participants were also required to provide their education level so that it was possible to infer the results on the content quality. Twenty-three questionnaires were collected, including eight by deaf users which focused on the usability and adaptability of the model (Figure 8).

The survey procedure was the same for both questionnaires. The users had access to a lesson within the inclusive MOOC, and after interacting with it, filled in an online questionnaire structured according to the Likert Scale, concerning usability, adaptability, and content quality, in which 1 corresponds to "strongly disagree" and 5 to "strongly agree".

Questionnaire on usability and adaptability of the inclusive MOOC for the deaf

Regarding the interaction you have just had with the prototype of a lesson developed following the inclusive MOOC pedagogical model, classify the following items according to your level of satisfaction, from 1 to 5, considering: **1-strongly disagree 2-disagree 3-neutral 4-agree 5-strongly agree**

		1	2	3	4	5
1.	The possibility to choose when to start or finish the lesson is very good.	☐	☐	☐	☐	☐
2.	The contents are interesting and well-structured.	☐	☐	☐	☐	☐
3.	For the deaf, the access to the contents using the automatic bidirectional translator, which translates text and sound into the Portuguese Sign Language, is effective.	☐	☐	☐	☐	☐
4.	The interface with the avatar makes the interaction with the contents easier for the deaf trainees.	☐	☐	☐	☐	☐
5.	The use of colours, graphs and images is appropriate.	☐	☐	☐	☐	☐
6.	The visual resources such as images, icons and diagrams help structuring and understanding the contents	☐	☐	☐	☐	☐
7.	The lesson contents are formally prepared to be accessed by a deaf individual.	☐	☐	☐	☐	☐

Figure 8. Questionnaire focusing on deaf users' satisfaction.

Questionnaire on usability and adaptability of the inclusive MOOC for the blind

Regarding the interaction you have just had with the prototype of a lesson developed following the inclusive MOOC pedagogical model, classify the following items according to your level of satisfaction, from 1 to 5, considering: 1-strongly disagree 2-disagree 3-neutral 4-agree 5-strongly agree

	1	2	3	4	5
1. The possibility to choose when to start or finish the lesson is very good.	☐	☐	☐	☐	☐
2. The contents are interesting and well-structured.	☐	☐	☐	☐	☐
3. For the blind, the access to the contents using the available audio system is effective.	☐	☐	☐	☐	☐
4. The interaction with the contents is clear and user-friendly for blind users.	☐	☐	☐	☐	☐
5. The audio resources available in the lesson are clear, and helpful for blind users to access the contents.	☐	☐	☐	☐	☐
6. The lesson contents are formally prepared to be accessed by a blind individual.	☐	☐	☐	☐	☐

Figure 9. Questionnaire focusing on blind users' satisfaction.

3. Results

The results are grouped and discussed per type of user based on the responses to the questionnaires addressed to deaf users and blind users.

3.1. Results of the questionnaire focusing on deaf users' satisfaction

Twenty-three questionnaires were collected, including eight by deaf users which focused on the usability and adaptability of the model (Figure 8).

From the twenty-three respondents to the questionnaire, most respondents were positive on the seven items, with an average of 70 per cent of the respondents selecting "strongly agree" as their responses. None of the respondents expressed any negative responses (Figure 10).

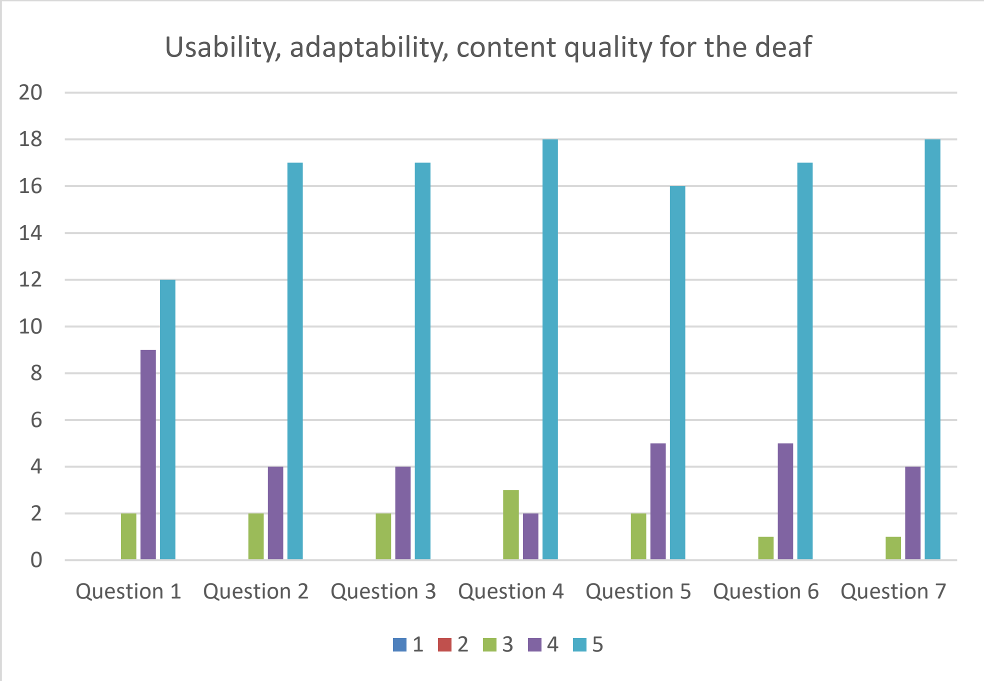

Figure 10. Results of the questionnaire focusing on the deaf users' satisfaction.

3.2. Results of the questionnaire focusing on blind users' satisfaction

Twenty-one individuals answered the questionnaire, six of whom were blind. Most respondents provided positive scores on the items, varying from 57.1 per cent to 66.7 per cent "strongly agree" responses (Figure 11). None of the respondents expressed any negative responses (Figure 11).

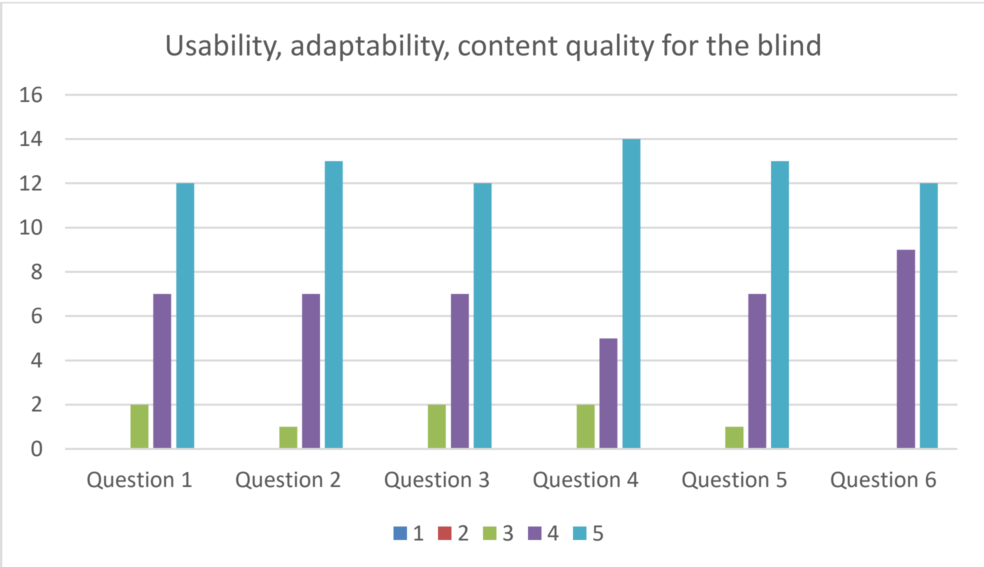

Figure 11. Results of the questionnaire focused on the blind users' satisfaction.

4. Discussion

The overall product quality of 82% – QEF results – is very encouraging and suggests that our approach has potential to create more inclusive didactic materials. There are still some improvements to be made, for example in the evaluation factor of the pedagogical domain (Figure 5), and in the usability factor in the ergonomic domain (Figure 6).

Regarding the users' perspective, both approaches were considered positive, with features addressing both blind and deaf people's needs when accessing digital content. Most respondents – more than 57 per cent – "strongly agreed" with the items "The lesson content is formally prepared to be accessed by a blind individual" and "The lesson content is formally prepared to be accessed by a deaf individual". Previous research highlighted the importance of developing virtual learning models for the deaf.

Regarding the main objective of the research, it was found that several studies suggested the development of strategies and tools for web-based education for the deaf In addition, there was a need to develop an e-learning system with a pleasing user interface. Despite these types of models, including assessment, system, architecture, and design, implemented in previous studies, just one LMS was found for communication between deaf and non-deaf people, developed at the National Institute of Education for the Deaf, in Brazil (Esdras & Galasso, 2020).

The process of creating multilingual (Portuguese/Brazilian Portuguese and the respective sign languages) courses explores the visual-spatial aspects of sign language in a digital process. A team of lecturers, educational designers, graphic designers, screenwriters, interpreter-translators, and specialized studio staff creates the digital learning objectives. The staff use project management methodologies which list specific tasks and organize the role of each member in the development of the activities. The visual language used is designed to touch deaf students conceptually and amusingly. Thus, the role of the educational designers is to make the learning experience effective while meeting the lecturers' aims for each course (Galasso et al, 2018).

The combination of these findings has encouraged researchers and practitioners to design and develop specific models with bilingual tools that will benefit both Deaf teachers and Deaf students.

5. Conclusion

This article presents an innovative MOOC developed to enlarge the digital educational offer for deaf people, also including a simple approach to blind learners. Deaf people are at clear disadvantage in education as their condition restricts communication with others and limits their access to digital content and information which is a critical factor in education. The inclusive pedagogical model and the proposal presented are designed to promote the development of inclusive and interactive learning environments. The intention is to minimize the barriers to access knowledge and education, enabling individuals with diverse needs to work together using the same educational materials. This will allow bidirectional communication in any language, which can be used in classrooms to create inclusive learning environments.

To control the quality of the MOOC and its potential to provide access to digital educational content, QEF was used. This is a framework that follows the development of the digital content and controls its production throughout the whole cycle. The results of the evaluation showed the positive potential of this model, even though further improvements are required, especially regarding the evaluation and usability features. To conclude, the proposed pedagogical model breaks the traditional inefficient process of communicating with/between people with various types of disabilities, to foster inclusion.

6. Recommendations

The model proposed in this paper as well as the methodology that was settled to create inclusive educational materials are a step forward to promote equity and inclusion in higher education. This approach addresses those students facing communication issues that prevent them to assess the content available in the majority language and channels and empowers them to benefit from a more effective learning experience by having access to digital content in a way they can swiftly explore. The core of the work performed so far was focused on deafness and sign languages; nevertheless, the features addressing blindness, although simplistic, have proved to be valuable and this line of work should be continued.

The MOOC developed as a proof of concept is just the first of a set of courses that will be delivered following this same approach.

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