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Proposed methodology for designing and developing MOOCs for the deaf community☆

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ABSTRACT

Massive Open Online Courses (MOOCs) have become important resources in educational environments worldwide because they have a positive impact on teaching and learning processes. Nevertheless, the way they are designed is crucial to properly address the requirements of special needs people in educational processes. Thus, this paper proposes a methodology for designing and developing MOOCs for Deaf or hard-of-hearing individuals. This exploratory and descriptive study adopted an inclusive education approach based on a literature review and expert consultation. The results highlight the importance of four aspects in MOOC development for these special needs individuals: (i) designing and incorporating elements that meet the needs of Deaf or hard-of-hearing people so that they can use MOOCs effectively; (ii) combining different methodologies and resources; (iii) properly planning and sequencing the design stages; and (iv) using appropriate tools, contents, and times for the process. The findings show that MOOCs should be adequately designed to address the demands of the Deaf community by considering their characteristics and requirements and incorporating current tools, practices, and resources.

1. Introduction

Massive Open Online Courses (MOOCs) have improved the educational offer and quality of educational systems, making them more universal through a more accessible and adaptable learning approach for students to assimilate knowledge. The purpose of these courses is to increase student equity and social inclusion. They serve socio-economically disadvantaged individuals and encourage institutions around the world to develop and implement programs that provide more equitable educational opportunities [1]. To design MOOCs, educational institutions should focus their efforts on collaboration, which makes these educational technology projects a challenge for institutional structures and participating actors [2].

MOOCs have some advantages over face-to-face courses in terms of flexibility, comfort, and access to education. As a result of these advantages, this type of courses are being widely accepted in multiple universities and becoming a popular modern learning and

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teaching method [3]. However, they are often reduced to a background role in different scenarios because they are not usually visible to the general public.

Although MOOCs are becoming increasingly popular and accepted, the dropout rates from these courses are high, which translates into many individuals not completing them successfully [4]. The dropout rate for this type of courses usually exceeds 80% [5]. In most cases, the reasons for dropout are beyond institutional control. For instance, Aldowah et al. [6] identified a set of factors that influence student dropout from MOOCs: academic skills, previous experience, course design, feedback, and other aspects related to students' social context. These factors can be used to identify areas that need to be improved and considered when MOOCs are designed.

According to Perna et al. [7], further research in this field should contribute to changing the characteristics of course design based on variations in students' outcomes. Thus, new methodologies for designing and developing MOOCs should be explored. Likewise,

Table 1
Review of existing methodologies for designing and developing MOOCs.

Author	MOOC design methodology	Summary
[8]	1. Rich media content: Course designers determine the way the content to be taught is presented. The course should be in an electronic format so that students and teachers can access it online. 2. Knowledge utilization: The course content is divided into knowledge units instead of class hours. Each knowledge unit is managed as an independent course unit. 3. Learning process management: This step involves autonomous and individual online learning; video streaming; answering questions; and performing tasks, tests, and assessments. Tasks and teaching activities should be formulated according to the curriculum. 4. Course teaching design: It contains teaching methods and teaching organization strategies that were selected according to the characteristics of the curriculum and the content of the chapters.	It is focused on the content used to design MOOC curricula.
[9]	1. Put together a multidisciplinary team so that teachers and assistants work together to create content, design activities, and select the ideal facilitator to guide the discussions in social tools. 2. Collaborate with specialists in your institution to design the course, adapt existing content, improve the quality of the material that is used, and deploy the course on the selected platform according to students' requirements. 3. Define a schedule from the beginning (and stick to it), taking into account enough time to design the course, generate the contents, test the course, and make the necessary adjustments at the end of the process (e.g., appearance and subtitling of the contents in the platform).	It details the steps in a methodology to design MOOCs successfully.
[19]	1. Data acquisition and assessment: In each module or unit, data are acquired in parallel from the outcomes of the activities that are conducted, as well as diagnostic and formative assessment. 2. Collaborative activities: The knowledge generated by participants can be used while and after the course is designed. There are three types of collaborative activities: common activities, which are "oriented to know the conceptual foundations and different visions and resources that are related to each profile"; group activities, which "take advantage of participants' heterogeneity, establishing connectivist activities"; and collaborative common activities, which aim to classify and organize the generated resources. 3. Resource management: The participation of MOOC students in collaborative activities generates knowledge. "It is necessary to manage these resources identifying and classifying all the generated knowledge in a continuous process."	It proposes a methodology to design adaptive MOOCs, i.e., sets of non-sequential micro-courses or individual modules with their own certification. The combination of these models in spiral results in more complex and wider-reaching competencies.
[20]	1. Special interest groups: The population is selected. Students fill out a questionnaire to classify them based on their teaching levels and subject areas. Then, teachers share useful resources before the beginning of the course. This is useful to adjust the curriculum. 2. Taking advantage of the crowds: Adequate tools are selected, and the collective intelligence of the MOOC participants is exploited. 3. Foundation strand and design strand: Different ways and levels of participation should be offered with interdependent modules related to each other. 4. Collaborative workbench: This "unified interface provides the design team with all the necessary information and functionality required for doing its creative work and group coordination." 5. Scripting across the curriculum: A script is developed based on the course objectives, for instance, "to learn about and experience a number of different technologies and resources for learning; to become familiar with a number of theoretical approaches and themes and have the opportunity to reflect on how these new ideas relate to their own teaching practices."	It describes several elements that should be considered to design the curriculum of collaborative MOOCs that adopt Knowledge Community and Inquiry, "where students engage with Web 2.0 technologies to develop a shared knowledge base that serves as a resource for their subsequent inquiry."

Zhang et al. [8] and Kloos et al. [9] have shared some new opinions, recommendations, and techniques (based on experience) regarding what a MOOC curriculum should include to meet the requirements of higher education and create adequate open online courses. They have also stressed the importance of aspects like materials; design; activities and evaluation; effects and impact; team support and services; information security; and intellectual property protection.

In this regard, tailoring existing content should be considered in MOOC design because using successful MOOCs might increase students' motivation, as suggested by Cernajeva and Volodko [10]. Therefore, considering the importance of MOOC design, this study proposes a methodology for designing and developing MOOCs for Deaf or hard-of-hearing individuals. This methodology incorporates aspects highlighted in several studies, expert perceptions, and the authors' experience gained while structuring a MOOC (which presented unique characteristics in terms of design and development).

MOOCs are powerful tools for educational access, but they can be inaccessible to people with disabilities if they are not designed with their needs in mind. Therefore, this study identifies the specific needs of deaf people in relation to these educational tools and suggests strategies to address them—thus adding value to MOOCs. In addition, it highlights the importance of monitoring student progress and using learning experiences to improve MOOC design. Educational institutions can replicate this methodology and adapt it to their needs to generate more inclusive and accessible content for people with disabilities.

The novel contribution of this study lies in its inclusive approach, its emphasis on user learning experience, and its standardization of MOOC design tailored to individuals with disabilities. These aspects provide a solid foundation for enhancing online education and promoting equitable learning opportunities for all. In a world where the number of individuals with diverse educational needs is constantly growing, an inclusive approach is paramount. Said approach provides meaningful and unique learning experiences that foster knowledge acquisition and skills development. Nevertheless, for this purpose, it is necessary to employ collaborative approaches, leverage existing resources, and integrate real-life scenarios to encourage critical analysis and problem-solving. Offering students the opportunity to apply concepts and theories to their environment promotes self-regulated learning, thus fostering engagement with their own development and the world around them.

2. Literature review

Student-centered education has been grounded in humanistic ideas. In particular, Rogers's humanistic theory [11] has been taken as a starting point for this type of education because it proposes a constructivist worldview of the individual, that is, the construction of experiential learning. This theory also applies to people with disabilities. The humanistic approach argues that the teacher–student relationship is essential for students because teachers become facilitators of learning. Under this premise, students are seen as goal-oriented individuals eager to learn and develop their own potential [12].

The philosophy of humanism reaffirms the dignity and value of people—the *raison d'ètre* of education is based on this paradigm. As a result, curricula should be designed adopting an inclusive approach, thus allowing people with special needs to become "what they are" and, in turn, reach their full human potential [13]. Humanism thereby becomes the fundamental principle of inclusive education as it creates the social and psychological conditions for universal participation in education [14].

In the case of MOOCs, the teacher–student relationship proposed in Roger's theory faces several challenges, including distance, cost, time, and continuity [15]. This relationship can be even more affected in the case of MOOCs for Deaf people, which is why some studies have proposed a humanistic teaching methodology for this type of courses [16]. It is worth highlighting that, as part of a disadvantaged group in online education, Deaf people require inclusive developments that support their learning process [17].

In summary, the educational objectives of humanistic learning theory are, in the words of Lu [18], to stimulate students' learning motivation, develop their potential and positive self, and empower them to learn how to learn, so that they can educate themselves and ultimately achieve self-realization. Likewise, it is important to spark students' curiosity during the teaching process, explore any unknown field based on their interests, and realize that everything is changing and evolving. Some MOOCs are following this methodology [16]. However, the elements that are necessary to design and develop MOOCs for Deaf people should be clearly identified so that teachers can foster independent learning and awaken students' curiosity [18].

2.1. Existing methodologies to design and develop MOOCs

Table 1 presents the methodologies that have been used in the literature for designing and developing MOOCs. This table also includes some of the activities conducted by different authors when these resources are designed, which will allow us to analyze how Deaf individuals participate in the construction of collaborative learning communities.

To meet the current demand for MOOCs that cater to the needs of all kinds of participants, course designers should consider people with disabilities, such as the Deaf or hard-of-hearing community, and their access to these courses. For instance, Paudyal et al. [21] proposed using MOOCs to address the challenges faced by these populations in education access because, on a global scale, the enrollment rate of Deaf and hard-of-hearing individuals is lower than that of the hearing population. Further research into the use of MOOCs for Deaf individuals is thus necessary so that they can access higher education, regardless of the institution or academic program they choose.

Rodriguez-Ascaso and Boticario [22] proposed user-centered design methodologies and outlined the requirements of MOOC learners who are hard of hearing, such as compatibility with technological platforms and an adequate presentation of the course content. Likewise, Gupta and Fatima [23] discussed the development of MOOCs for Deaf or hard-of-hearing individuals and concluded that all the course materials should include subtitles in the student's native language. Considering this, Table 2 presents some methodologies that have been proposed in the literature to design courses for people with disabilities, specifically Deaf or

hard-of-hearing individuals.

This review allowed us to identify outstanding aspects in all the methodologies that were analyzed. For instance, MOOC designers should consider a collaborative learning approach and a way to measure the effectiveness of this type of course for individuals with or without disabilities.

2.2. Aspects to consider in the design of MOOCs for deaf or hard-of-hearing individuals

When MOOCs are built, it is crucial to keep in mind the wide range of hearing difficulties that the Deaf or hard-of-hearing individuals may encounter, which, in turn, result in disparities in the learning process and utilization of technology tools. This also has an impact on how these individuals interact and cooperate with other MOOC participants. As stated by Gupta and Fatima [23] and Debevc et al. [26], developing MOOCs for Deaf people poses certain extra challenges compared to designing them for other target audiences. These hearing disabilities or limitations, according to Sanchez-Gordon and Lujan-Mora [27], come in a variety of forms, including deafness, decreased capacity of hearing, or inaccurate hearing.

The results reported by Fajardo et al. [28] indicate that deaf people may suffer from physical and mental disabilities because of their inability to hear or communicate. These disabilities are referred to as cognitive limitations, and they should be considered when courses that rely on online interaction and technology tools are developed. These limitations also explain why some deaf individuals have difficulty accessing well-rounded education. Another aspect to consider when inclusive courses are designed is that, if the volume of the audio material is not high enough compared to the background noise, hard-of-hearing students may not be able to hear it properly. To tackle this problem, a possible strategy is to control the volume at all times or use headphones or other devices [29].

In addition, using voice commands to operate a computer or technological devices is a challenge for many deaf people because

Table 2
Review of existing methodologies for designing and developing MOOCs for Deaf or hard-of-hearing individuals.

Author	Methodology for designing MOOCs	Summary
[22]	Student context: The situation is defined to identify current limitations. MOOC search and selection: It includes modeling the accessibility of the learning resources. Administrative tasks: Access to platforms (biometric identification techniques, learning schedule management, among others). Communication and collaboration: Selecting platforms and social networks to interact, such as Google Hangouts or Facebook. Resources (content and activities): Defining student access to course resources depending on their context.	User-Centered Design (UCD) is adopted to design and produce learning materials; e-learning accessible to all.
[23]	The development and production of MOOCs for Deaf students must consider: "Offering picture in picture capability of a prerecorded interpretation (by a qualified/certified interpreter) of the video content in the sign language of choice." Including class materials and sign language video of the course. Easy-to-understand videos for deaf and mute individuals.	It focuses on the essential elements that a MOOC should include to be accessible to deaf and hard-of-hearing students.
[24]	To design digital learning objects for deaf students, you should define: •the topic or subject, •who the collaborating teachers will be, •the type of contents that will be used, •how modules and lessons will be integrated, •the communication channels and the way in which student participation will be encouraged, •the platform that will be used, and •the mechanisms to market the course.	This empirical study proves that deaf students can acquire knowledge from a digital learning object.
[25]	The design of MOOCs for Deaf students must consider the following aspects: Defining learning modules and thematic content. "The content of the lesson should be no longer than 5 min and allow students to interact with the lesson every 3–5 min" "The content should be in the form of streaming media with text, images, and sign language interpreters that are clear, concise, and easy to understand." "The vocabulary used should be easy to understand and have important keywords to create more understanding." The examples or situations should be coherent and applicable to daily life. Images should be coherent with the content and different situations. "Learning and teaching through technology using online lessons and open learning resources." Activities that emphasize situations or cases that students should analyze to solve a problem. "Students can apply their learning to everyday life and develop self-regulated learning." "Measurement and evaluation should be consistent with the content by considering the development of assignments and activities." "Giving suggestions during activities will encourage learners to become confident in learning and taking test." "Interaction must be continuous throughout the activity. This will enable teachers to know children development and the part that should be promoted or improved."	Interaction and communication must be continuous throughout the course.

some of them were unable to learn how to speak or developed poor speaking skills from birth or at a very young age. Thus, there is a need for biometric alternatives other than voice commands so that these individuals can have access to such tools. In this regard, Rojas et al. [30] claim that these needs of Deaf individuals can be addressed by combining information technologies and artificial intelligence, thus enabling one of the most important elements of learning: communication.

For their part, Rodriguez-Ascaso and Boticario [22] point out that study materials or resources sometimes include sound without subtitles or transcriptions. This prevents deaf students from accessing online information and platforms, including course videos, which in general are not subtitled either. Likewise, according to Gupta and Fatima [23], many Deaf people communicate using sign language, which is different in every country and region. For instance, a study conducted by Cortés and Barreto [31] in eight cities in Colombia found a lexical variation of 54% in sports vocabulary. In particular, there are two or more signs for a single concept, which makes it difficult to standardize terms. Moreover, since this language is also completely different from Spanish, they see the latter as a second language in which they are not as proficient as native speakers.

Another essential consideration is that Deaf students may not be able to participate in a video or phone call unless special arrangements are made, such as the use of a sign language interpreter [32]. As a result, their interaction with other participants and the construction of collaborative learning is more challenging. This is in line with Gonçalves de Oliveira et al. [33], who argue that the challenge in designing MOOCs for Deaf individuals is mostly about them being a community whose language and culture are based on visual communication, i.e., far removed from the sounds used by hearing people. Furthermore, incorporating sign language by translating course contents and guidelines is still a novel aspect in this teaching approach.

3. Materials and methods

This study aims to propose a methodology for designing and developing MOOCs for Deaf or hard-of-hearing individuals. For that purpose, we adopted an exploratory descriptive approach to find as much information as possible about the topic addressed here and identify some of its characteristics and those of the population under analysis [34]. In this case, such characteristics are related to resources; specific course design features (e.g., learning objectives and content); and the needs of the target population, which are crucial when designing MOOCs for Deaf people. This study also adopted a qualitative approach in which primary and secondary information sources were identified and analyzed. The methodology proposed in this paper is divided into four phases (see Fig. 1).

In the first phase, we identified existing methods for MOOC design, focusing on hard-of-hearing participants and their access to

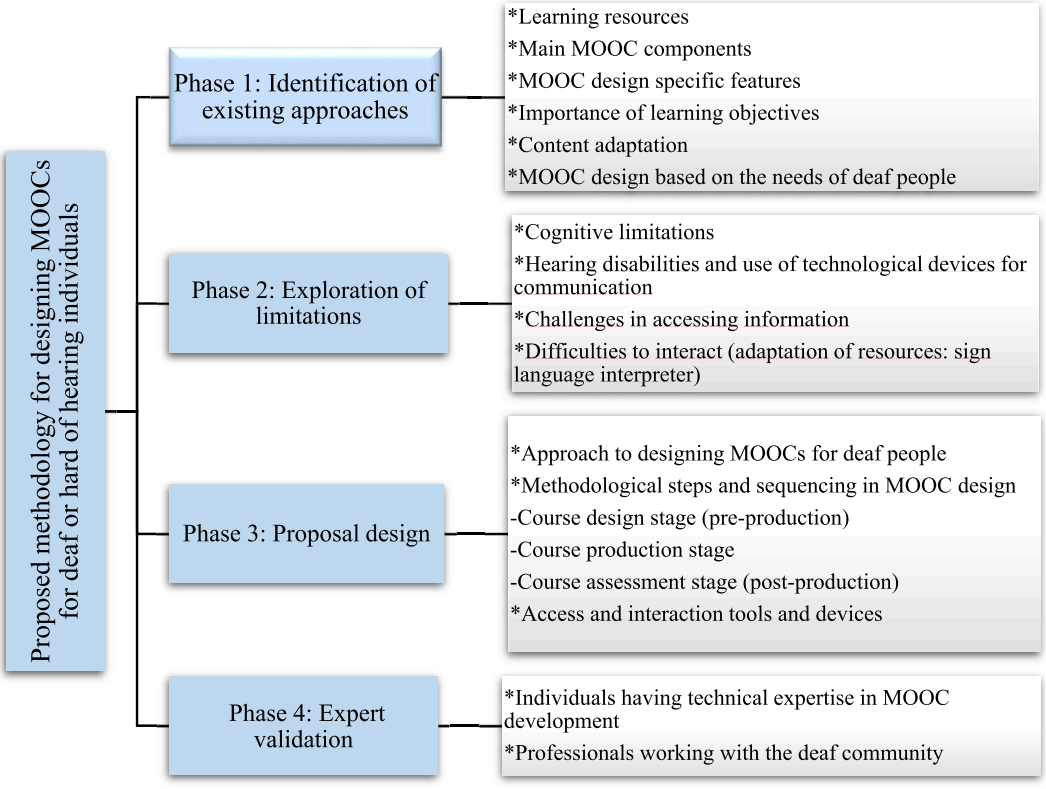

Fig. 1. Proposed methodology for designing MOOCs for Deaf people.

education in online learning environments. Therefore, we conducted a literature review on the approaches or aspects that are generally used to design and develop MOOCs. The purpose was to determine the unique characteristics of these resources and propose a novel alternative to define and structure their design.

In the second phase, based on the literature, we described the limitations and some cognitive difficulties caused by several types of hearing impairments, as well as communication issues due to the use of technological devices. We also outlined the challenges faced by the Deaf or hard-of-hearing population in accessing information and interacting, which often requires using sign language in educational resources depending on the characteristics of all the participants and the level of hearing loss [35]. In the third phase, we formulated our methodological proposal to design MOOCs for Deaf or hard-of-hearing people. This proposal takes into consideration the importance of constantly looking for solutions to the challenges and needs that may be observed in the education field, particularly among people with special needs [36]. In this phase, we described the most appropriate design approach, methodological steps, and sequence for MOOC design, as well as the access and interaction tools and devices that are necessary to set up these resources.

In the fourth phase, our proposed methodology was validated by a group of experts. To define its most critical aspects, we required the support of individuals who are highly qualified in the design and development teaching resources and technologies for the Deaf population and are closely related to the Deaf community in the academic and business contexts. For instance, we interviewed three engineers specialized in information technologies and content generation on technical aspects of MOOC development. In addition, we received the support of two therapists, six scholars, two instructors, two sign language interpreters, and four volunteers from a foundation that offers guidance to Deaf people. All these professionals have wide experience in the field and direct contact with the Deaf community in educational settings. The administrative staff and researchers from the institutions involved in the project were also consulted. Furthermore, to include the business sector, two human resources managers from a well-known industrial and commercial company—who have Deaf people in their teams—were interviewed. Finally, two professionals involved in a business program aimed at promoting the employment of people with disabilities in Medellín also participated in this process.

These experts were selected based on the criteria defined by Cabero and Llorente [37], i.e., their academic level, field, and work experience. In addition to these criteria, it was also crucial to establish their suitability and potential contribution (as they would need to assess specific matters from their own perspective), as well as their utilization of multiple resources or strategies to analyze complex or novel topics and contents.

The above was complemented with the direct participation (through interviews) of 22 Deaf students from different academic programs (political science, law, social sciences, graphic design, mathematics, physics, and business management, among others) in several higher education institutions in Medellín.

In consideration of the fact that this article emerges within the framework of research project with code P20232, entitled 'Methodological Proposal for the Design and Development of MOOCs Aimed at Strengthening Work Competencies in the Deaf Population of the City of Medellín,' it is important to highlight that said project was approved by the Ethics Committee for Scientific Research of the Metropolitan Technological Institute of Medellín, Colombia, presided over by Dr. Eduard Alberto García Galeano. Following a thorough review of the documentation related to the proposal, this committee assessed the project as posing 'MINIMAL RISK.' Consequently, it granted the APPROVAL (804) for its execution. Furthermore, informed consent was obtained from all participants at different stages during the data collection process, explicitly outlining the conditions of the interview, handling of information, protection of privacy, and security of interviewees' data.

4. Results

After analyzing the methodologies that are commonly used to design and implement MOOCs and the challenges faced by Deaf individuals to access these courses, this section discusses the main findings of this study regarding the proposed design methodology, the methodological steps, and the recommended sequence. It also presents some tools and devices that can be considered in MOOC design so that deaf users can have access to the resources and interact.

4.1. Proposed methodology for designing MOOCs for deaf or hard-of-hearing individuals

According to the Committee on the Rights of Persons with Disabilities (CRPD), people with special needs should be able to fully participate in all aspects of life, including education [38]. Thus, MOOCs—thanks to their characteristic of providing open online education to many individuals—have the potential to address the learning needs of millions of people while also fostering the inclusion of Deaf individuals [39], especially supported by Information and Communication Technologies (ICTs) [40].

There is much debate in the literature regarding the challenges associated with the implementation of these massive courses. For instance, Rodríguez-Ascaso and González Boticario [36] hold that educational institutions should make sure that MOOC participants with and without disabilities enjoy equal conditions. Moreover, some empirical evidence indicates that MOOCs, which take advantage of educational technology, allow populations with limitations or disabilities to better assimilate and acquire knowledge in several fields [24]. Likewise, according to Sanchez-Gordon and Lujan-Mora [27], the barriers to access and communication in online learning environments (e.g., MOOCs for deaf people) may be eliminated by employing adequate approaches.

> Hence, the instructional design of a MOOC for deaf people must consider the communication difficulties related to the features of the written language of a high percentage of the Deaf community. In fact, their written language has been usually characterized as containing grammar mistakes, as well as lacking flexibility and being highly complex [41]—which is why sign language is the most widely used means of communication by this community [42]. Since they learn through visual

communication, it seems logical to include sign language as a solution to the communication barriers that have been identified regarding their written language. Additionally, it is critical to understand the difficulties that Deaf individuals face, as well as the strategies that have been proposed to address their needs, including the use of online tools that facilitate interaction through videos. Therefore, their entire learning process, including the methods to test their mastery of knowledge, should be video-based.

In general terms, our methodology includes three important aspects: (1) a proposed approach to design MOOCs for Deaf people; (2) methodological steps and a sequence to design these MOOCs; and (3) interaction and access tools and devices to be considered in this design process. These three aspects—described in the following subsections—include not only the step-by-step procedure that should be followed but also the implementation of tools that can help Deaf people overcome certain difficulties that they encounter when they take tests in sign language.

4.2. Approach to designing MOOCs for deaf or hard-of-hearing individuals

According to the literature on MOOC design, courses aimed at Deaf communities should focus on developing their life and job skills. In addition, these online learning environments should enable them to complete assignments and access knowledge via technology tools [25].

Several studies also suggest the combination of two strategies or approaches to design MOOCs. For instance, they have recommended the implementation of connectivist Massive Open Online Courses (cMOOC), which are based on a socially constructivist learning approach that is flexible and sensitive to the specific needs of participants [43]. Blum-Smith et al. [44] discussed the learner-centered design approach, which is governed by the following six principles identified by facilitators: "giving up control" (accepting that there are many elements in the learning environment that teachers cannot control); "distributing facilitation" (encouraging participants to take on leadership roles, such as those of teachers, and positioning facilitators as learners); "being live" (taking advantage of synchronous and asynchronous spaces to create community and connections among participants); "amplifying" (highlighting the wealth of ideas and actions in the course by making the work of participants visible); "modeling" (modeling learning to foster participants' individual expression and creation); and "being explicit" (communicating participants' ideas or opinions about their learning experience and course activities).

To formulate the methodology proposed in this study, we incorporated some of the characteristics mentioned above, as well as aspects taken from the experts' opinions and their experience developing MOOCs for Deaf or hard-of-hearing individuals. Based on this, we were able to identify specific conditions and elements that could improve the development of these courses.

4.3. Methodological steps and sequence to design MOOCs for deaf or hard-of-hearing individuals

From a holistic perspective, our proposed methodology for designing MOOCs for Deaf individuals is based on three sequential stages traditionally employed in course design: course design (pre-production), production, and assessment (post-production). Importantly, the first two stages are sequential, whereas the assessment stage can take place simultaneously with the other two stages. Our proposal, however, is implemented in a more comprehensive manner to make improvements to the MOOC *while* it is being

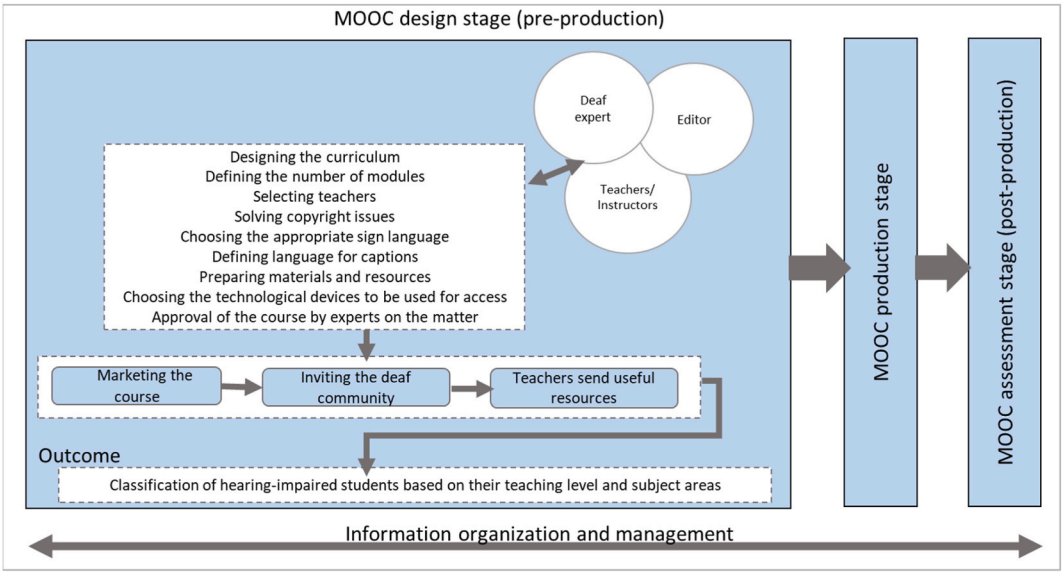

Fig. 2. First stage (pre-production) of MOOC design for Deaf people. Note: Adapted from Refs. [24,45–47].

developed. Also, it is built upon some recommendations by Seidametova [45], who agrees on the three stages mentioned above and, in addition, suggests some activities regarding course design and the use of special technology tools for Deaf people.

We also considered the following aspects outlined by García et al. [46] for MOOC design: (1) curriculum or pacing guide, (2) methodology, (3) content organization and storage, (4) quality of the information and content, (5) educational resources, (6) ability to motivate, (7) multimedia tools, (8) language, (9) discrimination and values, and (10) participants' special characteristics.

4.3.1. *Course design stage (pre-production)*

In the first stage, MOOC designers should understand the scope of the course and preliminary information that is necessary to plan and build it. Each planned activity must include a description of the elements that it uses or requires so that the target audience (in this case, the Deaf community) experiences the course exactly as intended for them. This first stage (pre-production) should include the following activities (which are summarized in Fig. 2).

- Designing the curriculum and setting the learning objectives (by calculating cost, capacity, quality, and duration)
- Defining the number of modules and learning outcomes for each module
- Selecting teachers
- Avoiding and solving issues related to copyright and availability of materials
- Choosing the appropriate sign language and language for captioning based on the region or country where the Deaf students are located
- Preparing video materials, scenarios for lessons, tests, and interviews per module or weekly unit
- Choosing technology tools and devices that facilitate human–machine interaction for the target audience, focusing on graphic and voice interfaces that enable users to access the course contents
- Prior approval of the course by experts in the specific field and the target audience
- Marketing or promoting the course
- Inviting Deaf people to enroll
- Classifying Deaf students based on similar teaching levels and subject areas so that teachers can share useful resources with them before the course starts

This stage requires the course to be promoted in sign language as well. Users will thus have access to course information not only in written form but also in a more visual format, such as a video in sign language. Video clips used in MOOCs for Deaf people play a crucial role in their experience and learning process because they tend to be more appealing and interesting than plain text [25]. For this reason, the curricula, learning objectives, and modules of these MOOCs should always include videos in sign language with captions in Spanish to accommodate oral deaf people and Deaf individuals who use sign language.

4.3.2. *Course production stage*

In the second stage, course designers establish how the course unfolds and the collected information is managed. This stage should incorporate the following activities (which are summarized in Fig. 3).

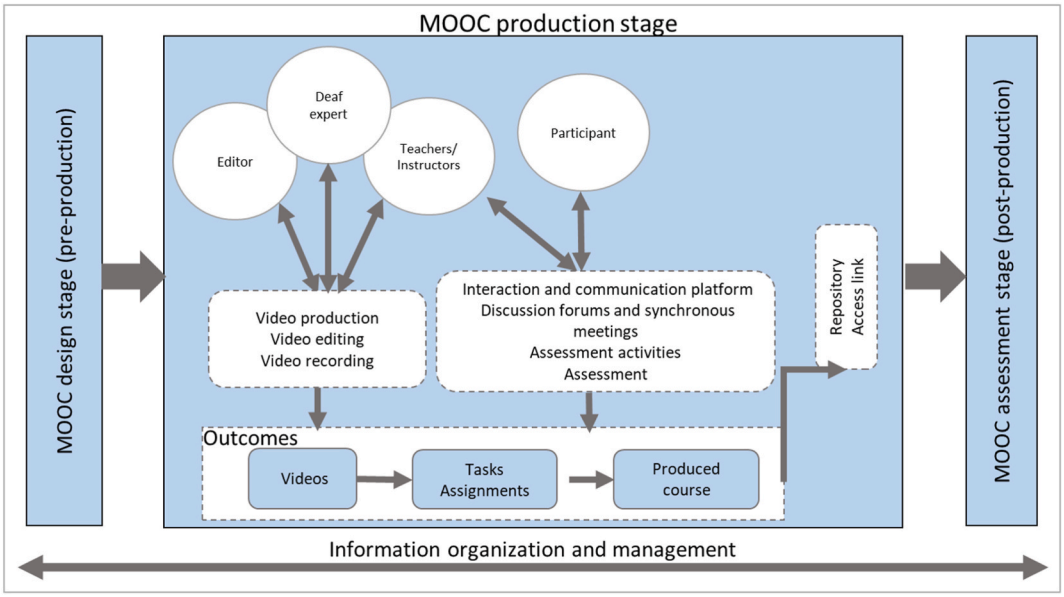

Fig. 3. Production stage of MOOC design for Deaf people. Note: Adapted from Refs. [24,45–47].

- Organizing and managing information
- Finding alternatives to store information in repositories and accessing it using a direct link
- Preparing sessions, videos, and tasks
- Recording lectures and interpretations so that they can be watched offline
- Planning assessments

At this stage, it is necessary to make it clear for those involved that the course will be *delivered in sign language* for Deaf individuals—thus differentiating it from a sign language course for hearing people. Considering this, all the videos should include two shots: one of the teacher's face and another one of the interpreter. The two shots must be the same size to attach the seam importance to both of them because interpreters and their role of communicating the content are highly important in this type of MOOCs. Whiteboard videos are also recommended as a method to illustrate course content and reinforce it in the last unit. This would, in turn, help users to evaluate course content in the final activity.

4.3.3. Course assessment stage (post-production)

In the third stage, course designers can evaluate the training provided and participants' satisfaction with the course.This stage should consider the following activities (which are summarized in Fig. 4).

- Implementing assessments, discussion forums, video quizzes, and/or projects specifically for Deaf people
- Carrying out fun activities based on gamification to test mastery of knowledge
- Using an evaluation form to test mastery of knowledge, which may include exams with multiple choice questions that are graded automatically and/or oral tests in synchronous spaces
- Using an evaluation form to measure student satisfaction and content quality
- Incorporating activities that require analysis in discussion forums
- Conducting peer evaluation activities
- Describing the tools and strategies that Deaf students will use to access and take exams (such as new devices with voice output or a special keyboard with voice control for those who can speak, considering participants' initial classification), which require captions and subtitles
- Generating reports and statistics of each participant
- Receiving feedback from Deaf students on assessment activities
- Possible dissemination and participation in lectures and seminars
- Discovering new lines of research based on the results obtained
- Recording users' opinions about their experience with the course, which is very important

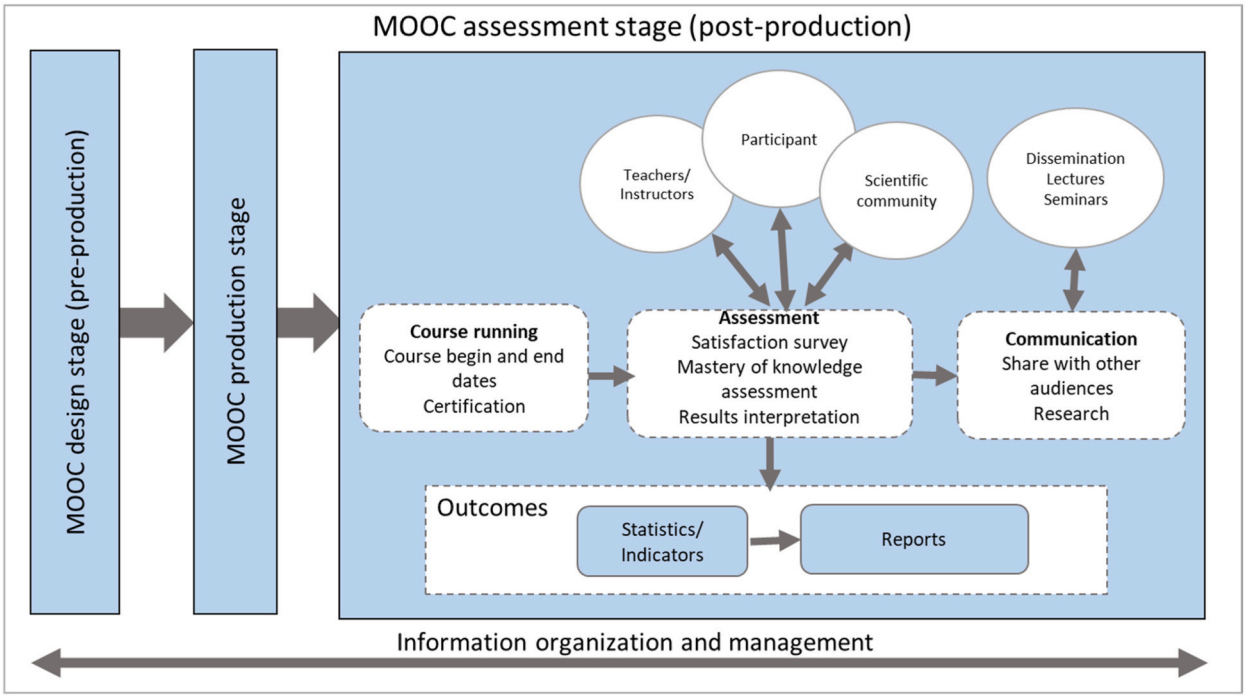

Fig. 4. Assessment stage (post-production) of MOOC design for Deaf people. Note: Adapted from Refs. [24,45–47].

In this assessment stage, learners' comments are also considered to make continuous improvements. Simultaneously with the activities in these three stages, course information and resources are saved in available storage space on a server, which makes it possible to access and search for content.

4.4. Access and interaction tools and devices to consider when designing MOOCs for deaf or hard-of-hearing individuals

Regarding communication and interaction, some free tools can be used depending on participants' level of disability, e.g., WhatsApp, Facebook, Messenger, and Twitter. These apps allow teachers to send and receive videos in sign language [47].

The course content should be delivered via streaming media with clear, concise, and easy-to-understand text, images, and sign language interpreters. There are open-source tools such as H5P that can be used to adapt and simplify texts so that students can learn independently without the support of an instructor. This tool also includes videos and interactive exercises for students to test what they have learned in the course. Users are thus able to practice what they have learned in their native sign language [48]. Genially is a freemium resource that can be used to create online interactive content for skills development. This tool allows users to design charts, presentations, interactive videos, and assessment activities in sign language [49].

Finally, Flipgrid is a relatively easy-to-use educational tool for recording videos. It is a lot like popular social networks such as Instagram or Snapchat, and it is considered a useful resource to build a sense of social presence and community among users. It is a well-intended inclusive app, and it can be used to create exclusive experiences for Deaf students and conduct peer evaluation activities [50].

Since gamification strategies can increase student motivation in MOOCs, game-based learning activities could be designed in sign language to support the learning of Deaf individuals [51]. For instance, in the study by Saman et al. [52], a multimedia application developed using gamification was employed to teach lessons effectively and efficiently to Deaf children. Similarly, Ramos-Ramirez and Mauricio [53] created a videogame for teaching Spanish to deaf children. Therefore, gamification can be a useful learning strategy for Deaf people because it makes them feel more motivated in different educational settings.

4.5. Other general aspects to consider

- Participants' heterogeneity should be exploited to learn from student diversity and improve quality indicators.
- The purpose of creating MOOCs is to improve the quality of education by strengthening horizontal bonds between those involved and encourage collaborative learning in student groups.
- Since lessons should be easy to assimilate, their content should be no longer than 5 min. Additionally, each lesson should include a space of at least 3 min for participants to interact.
- The vocabulary should be easy to understand, and keywords should be included to ensure better comprehension. If examples are to be employed, they should be applicable to daily life. Images should be consistent with the content and situations so that they are easier to interpret.
- In activities and assessments, participants should be given enough time to read and grasp the information.

5. Discussion

According to the results of this study, MOOCs have expanded the educational offering and improved educational processes, allowing more people to learn about a variety of topics in several fields of knowledge and develop multiple skills based on their individual capabilities or characteristics, time, and other available resources. Thus, as stated by Escudeiro et al. [54], these courses facilitate access to education for a greater number of individuals with specific needs. This is especially relevant if we take into account that the number of people with diverse disabilities that want to have access to education is growing every day, and yet different educational institutions have failed to satisfy their learning needs [55]. It is therefore imperative that people with disabilities be included in educational systems, particularly in less developed countries where access and exclusion difficulties still exist in different social contexts [56]. In addition, MOOC-based educational processes have emerged as a flexible alternative to provide access to learning opportunities, and they continue to evolve, especially when it comes to the education of individuals with special needs. The following subsections describe the possible social, theoretical, and practical implications of this study.

5.1. Social implications

This study found that different aspects considered in MOOC design (e.g., quality, attitudes or behaviors, accessibility, and satisfaction) are crucial for the successful deployment of this type of resources. This is in line with the findings of Sanchez-Gordon and Lujan-Mora [27], who emphasized the importance of MOOCs' open and massive nature. As a result of these characteristics, MOOCs can eliminate possible accessibility barriers that limit the inclusion of individuals with or without disabilities. Nevertheless, course designers should ensure the quality of the resources; materials; activities for knowledge appropriation, assimilation, and sharing; and assessments proposed in the process.

As considered in our proposed methodology for designing MOOCs for Deaf people, the resources used in these courses should be tailored to the target audience because, despite technological advances and new educational opportunities, some individuals,

specifically those with disabilities, still have difficulties accessing education. This was also mentioned by Shinohara et al. [57], who found noticeable differences in access to education between disabled and non-disabled individuals. Thus, failure to tailor courses to the needs of individuals with disabilities and their limited research possibilities have resulted in their low participation in MOOCs. In this regard, Gleason et al. [58] recommend creating more flexible and accessible technologies and strategies to address the needs of different populations.

Considering the above, MOOC design should change to expand the scope of these courses and improve their completion rates because, despite their popularity at universities in developed and developing countries, MOOCs have a high dropout rate. Therefore, to counteract this phenomenon and enable the inclusion of diverse populations, these courses must be effectively adapted. These changes should focus on adequately designing course materials, activities, interaction processes, and assessment activities.

Our proposed methodology also reveals the current need for developing methods to design user-centered MOOCs because they offer students meaningful and unique learning experiences that help them acquire knowledge and develop skills. MOOC designers should not limit their users' cognitive potential but instead allow them to engage in adequate practices that enhance their learning [59].

5.2. Practical implications

Our findings also encourage the development of collaborative design approaches and the use of existing resources (e.g., devices, applications, platforms, and social networks) so that participants can continuously interact and share ideas throughout the course. Additionally, the content should include real-life scenarios or situations for students to analyze critically and provide solutions to problems in their surroundings, thus enabling them to put concepts and theories into practice and develop self-regulated learning. This is consistent with Barata et al. [60], who proposed integrating technology and learning so that the communication and cooperation between individuals with specific needs result in digital artworks. Therefore, these individuals can take the lead because they feel included and an essential part of their own development and the world around them.

For that purpose, the different needs of Deaf people should be identified. MOOC designers should consider the difficulties or deficiencies that these individuals have developed because of their hearing problem and prior knowledge, which may affect their understanding of topics and assessment components, as well as their use of the technologies necessary to participate in the course. In this respect, Susetyo et al. [61] found that Deaf students were not be able to properly understand certain exam questions because they included vocabulary that was complex for them. Based on their results, these authors hold that we need to devise strategies to improve and standardize the designs, methods, and tools employed along the stages of the learning process of Deaf people. As a result, this community would be able to enjoy their fundamental right to education in the so-called knowledge society.

Importantly, so far, MOOC design has not been standardized deployedfor the educational context, especially when it comes to the challenges faced by Deaf or hard-of-hearing individuals. This study is thus relevant because it identifies possible distinguishing characteristics of Deaf people, as well as their main needs when learning via MOOCs. From this perspective, an educational diagnosis should be applied to the course design, plan, and description in order to take full advantage of these learning resources. Therefore, those involved in adapting MOOCs are encouraged to analyze, interpret, and design these teaching and learning tools based on the specific needs of these individuals to offer them satisfactory mechanisms to address their specific requirements.

Similarly, Rosas-Magallanes et al. [62] highlighted the importance of four aspects: (i) the teaching strategies designed to address the unique characteristics and needs of the course's target audience, (ii) the will and commitment of those in charge of educational environments, (iii) the flexibility of the technological and educational models adopted by different institutions and those involved in the process, and (iv) the continuous monitoring of students' progress. In addition, universities should constantly keep themselves up to date and offer training on changes in technological tools, and instructors should receive timely support to provide a service that brings positive experiences to participants.

Based on the ideas analyzed here, educational institutions and those involved in the design and implementation of education policies and actions should reflect on the coherence between the latter and students' needs. They should also acknowledge the need for monitoring students' progress throughout courses and utilizing the learning experiences resulting from the process. These experiences serve as inputs for continuous improvement and to prevent potential flaws that may cause misalignments in course design, content, methodologies, technological resources, and strategies.

5.3. Theorical implications

This study also has several theoretical implications that should be highlighted. On the one hand, it proposes a methodology for designing and developing MOOCs for Deaf people based on the needs of this population and the experience of experts who have guided their learning processes. This proposal—grounded on humanistic theory—promotes the inclusion of people with special needs in virtual education. On the other hand, it discusses the limitations, challenges, and strategies that should be addressed to respond to the real needs of Deaf communities worldwide. Consequently, the findings of this study can be input for educational institutions that develop MOOCs aimed at this population.

Before a MOOC is implemented, course designers and administrators should assess the characteristics of existing MOOCs that are offered to vulnerable populations. As a result, they can have points of reference to tailor the course structure and focus on the needs of students with special needs, thus enabling more inclusion and differentiated instruction [63]. This is consistent with Fernández-López et al. [64], who found that adapting the tools used in educational processes (user interfaces and content) has a positive effect on users' learning because it focuses on their requirements in order to provide them with high-quality educational opportunities that contribute to their overall development.

5.4. Limitations

The main limitation of this study is that its approach is merely descriptive, and it is not applied to a real environment (i.e., an experiment). Hence, future studies could focus on the implementation of this methodology in real contexts. Another limitation is related to the literature review because it does not include an exhaustive and comprehensive analysis of the MOOCs that have been developed for the Deaf community. Therefore, a future line of research could be a systematic literature review to understand what has been done in terms of MOOCs for the Deaf population and what improvements can be made in the current ever-changing world.

6. Conclusions

Designing and developing MOOCs is challenging for all those involved in their production. And it is especially challenging when MOOCs are developed specifically for people with cognitive and physical disabilities because these resources should be tailored in terms of format, content, assessment activities, tools, devices, and interaction dynamics according to their prior knowledge, capabilities, and needs. Nevertheless, it is an opportunity to increase inclusion by enhancing the accessibility, flexibility, and quality of the tools in the MOOCs. This should result in a better performance, acceptance, and successful completion of these courses.

The results of this study highlight the importance of three aspects in MOOC design: (i) updating and combining flexible strategies, methodologies, and resources in the activities; (ii) focusing on students' needs to address special circumstances and conditions; and (iii) promoting constant interaction and feedback between those involved in the educational process through a variety of means and formats that foster connections and the construction of collaborative knowledge based on significant experiences. These aspects can cause MOOC-based learning to be more highly valued.

According to our findings, the adequacy of the methodological steps and sequence in MOOC design is a decisive factor that influences the assessment of the learning process of users, especially Deaf or hard-of-hearing people. In addition, there are several key elements that should be considered when MOOCs are designed for these populations, e.g., accurate planning and selection of resources, materials, equipment, and staff; promotion of education; content and information management; student diagnosis; participation; and assessment.

> Furthermore, MOOC design should incorporate multiple tools, applications, and devices that facilitate participants' access and interaction (e.g., messaging apps, social networks, gamification tools, and sign language dictionaries). The materials should include clear, accurate, and adequate texts, images, and sign language interpretations; and students should be given enough time for the activities, as well as continuous support. Finally, MOOC designers should take advantage of participants' diversity to continuously enrich this learning method and process.

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Author contribution statement

Alejandro Valencia-Arias: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Orfa Nidia Patiño-Toro: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Andrés Fernández-Toro: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Alexander Jiménez-Guzmán: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

Carlos Augusto Puerta-Gil: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Data availability statement

Data will be made available on request.

No additional information is available for this paper.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e20456.

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