ACCESSIBILITY CONSIDERATIONS OF MASSIVE ONLINE OPEN COURSES AS CREDITABLE COURSES IN ENGINEERING PROGRAMS

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Abstract

This paper proposal is to include MOOCs (Massive Open Online Courses) as creditable courses in engineering programs at the National Polytechnic School of Ecuador. In addition to fulfilling a number of requirements related to the content and duration of the courses, one important challenge is that these selected MOOCs should comply with web accessibility requirements specific for the special needs of non-native speakers.

Web accessibility is the property of a website to support the same level of effectiveness for people with disabilities as it does for non-disabled people. As an accessible website is designed to meet different user needs, preferences, skills and situations, this flexibility also benefits people without disabilities in certain situations, such as MOOC students who are non-native speakers. Unfortunately, MOOCs raise new challenges on web accessibility. For example, cultural differences and background knowledge have to be taken into account when choosing contents, examples, and learning activities which might be unfamiliar or even offensive to certain cultures. Also, user interfaces requires special adaptations for non-native speakers.

We present a preliminary list of web accessibility requirements and highlight the challenges non-native speakers experience when using MOOCs. The goal is to raise awareness about the particular needs of non-native speakers. This understanding will be the base for establishing criteria for a preliminary selection of MOOCs as creditable courses in engineering programs at the National Polytechnic School. These criteria can also be useful for other higher education institutions interested in including MOOCs in their official programs.

Keywords: Engineering Curriculum, Massive Open Online Courses, Web Accessibility, Web Content Accessibility Guidelines, User Interface, Non-native speakers.

1 INTRODUCTION

In order to include MOOCs (Massive Open Online Courses) as creditable courses in engineering programs at National Polytechnic School of Ecuador, it is necessary to identify both general and accessibility requirements. Currently, the curriculum of all the engineering students at the National Polytechnic School includes an elective subject of three credits chosen from the course offer of the university. The idea is to provide lists of selected MOOCs to expand the options of elective subjects that students can choose. In addition to fulfilling a number of requirements related to the content and duration of the courses, one important challenge is that these selected MOOCs should comply with web accessibility requirements specific for the special needs of non-native speakers. These requirements should take into account cross-cultural issues and language barriers.

In the following sections, we present background context for MOOCs, web accessibility, flipping classroom approach, the engineering programs at National Polytechnic School of Ecuador, as well as we propose general requirements and accessibility requirements to be taken in account in MOOCs, a method for selecting credit-worthy MOOCs, and conclusions.

2 MASSIVE OPEN ONLINE COURSES

Massive open online courses (MOOCs) possess two defining characteristics that differentiate them from previous online courses that have existed for decades. First, a MOOC is open and free of charge, meaning that anyone with Internet access and willing to learn the subject can use it. Second, a MOOC is massive, meaning huge number of students register to it [1]. Other than being open and massive, MOOCs don't differ much from other online courses: a syllabus, a calendar, educational materials

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(mainly videos), some activities or projects, quizzes (usually multiple choice questions) to assess students learning, and a forum to discuss with instructors and fellow learners.

The story behind our proposal has many possible beginnings. It could begin as far as 1728, when distance learning is born with a U.S. course on short-hand offered via correspondence. The advertisement of this course stated that any "Persons in the Country desirous to Learn this Art, may by having the several Lessons sent weekly to them, be as perfectly instructed as those that live in Boston" [2]. Another possible beginning is in 1976, when UK Open University offered three courses online, thus inaugurating the era of online distance learning. Or this story could begin in 2008, when Dave Cormier coined the term MOOC to refer to the online course "CK08. Connectivism and Connective Knowledge" offered by Canada's University of Manitoba, which had 25 students enrolled for credit plus 2,300 tuition-free students from the general public [3]. As noted by Pence [4], "this course was highly social in format, experimental, non-linear, and participatory. This interaction resembles that in a massively multi-player online game (MMOG), which was the basis for calling this format a MOOC".

In 2011, the Computer Science Department of Stanford University experimentally offered three online courses to the public for free: "CS221. Introduction to Artificial Intelligence", "CS145. Introduction to Databases", and "CS229. Introduction to Machine Learning". The enrollments were 160,000, 60,000, and 100,000 public students from 190 countries.

In 2012, three different MOOC platforms appeared: Coursera, Udacity, and EdX [5]. The first two are Stanford´s spin-offs created by teachers that participated in the first experimental MOOCs. Coursera's vision refers to "a future where everyone has access to a world-class education that has so far been available to a select few" [6]. Coursera is the leading MOOC platform with 4.5 million students, 447 courses, and 84 partner universities and educational organizations from all over the world. Coursera offers MOOCs in English, Chinese, French, Spanish, Portuguese, Turkish, German, Russian, Ukrainian, Arabic, Italian and Japanese. The Massachusetts Institute of Technology and Harvard University founded EdX, currently with 72 courses and 675,000 students. Udacity advocates to "democratize higher education" with a current offer of 28 courses and 1 million students [7]. Some courses have achieved astonishing success, getting nearly a quarter of a million participants, as Coursera's MOOC "Think Again: How to Reason and Argue" [8].

In 2013 appeared MiríadaX, an Iberoamerican MOOC platform that currently hosts 57 courses from 20 universities, mainly from Spain, a joint effort of Universia Network, Telefónica and Banco Santander [9]. On September 2013, appeared FutureLearn, a UK's MOOC platform, with 20 courses and 26 partners, including universities and cultural institutions [10].

3 MOCCS AS CREDITABLE COURSES

In February 2013, the American Council on Education (ACE), an organization that advises U.S. universities on policy, recommended to award credits for five Coursera's MOOCs: "Algebra", "Pre-Calculus", "Calculus: Single Variable", "Introduction to Genetics and Evolution" and "Bioelectricity: A Quantitative Approach"; and four Udacity's MOOCs: "Elementary Statistics", "Entry-level Mathematics", "College Algebra", and "Introduction to Computer Science".

Colorado State University accepts three transfer credits for students that own a "certificate of accomplishment" for Udacity´s "Introduction to Computer Science" and pass an exam in a testing center. About 200.000 students have registered in this course. However, up to date none had solicited credit.

Antioch University offers college credit for two Coursera's MOOCs: "Greek and Roman Mythology" and "Modern and Contemporary American Poetry". Pilot students that enroll in these courses get the guidance of an Antioch´s teacher, also enrolled in the course, who acts as facilitator, discuss the material with the students and assigns supplemental work.

Georgia Institute of Technology has patterned with AT&T and Udacity to offer an accredited online master in Computer Science entirely through MOOCs, starting fall of 2014, to up to 10.000 students. This proposal is not free of charge. Nevertheless, at $7.000, it is a sixth of the regular cost. The individual MOOCs will still be open for free to non-degree non-credit participants [11].

Wharton School of the University of Pennsylvania published four MBA courses in MOOC format at Coursera. The non-credit courses offered are "An Introduction to Financial Accounting", "An

Introductions to Operations Management", "An Introduction to Marketing", and "An Introduction to Corporate Finance".

In the European Union context, Technical University of Munich, Free University of Berlin, University of Salzburg, among others, accept credit transfer for MOOCs [12].

In the Iberoamerican context, the "Report on Higher Education in Iberoamerica 2012-2017" [13] explores emergent technologies and its potential impact in the region. MOOCs appear as a new topic with an implementation horizon of five years. Their potential lies in the fact that the course materials and the course itself are free and open access, and students who complete a MOOC might apply for credit transfer. This way, MOOC broaden the access to higher education by offering learning experiences beyond a particular university [13].

Nevertheless, according to Laplante [14], some universities don't recognize credits for MOOCs because "they don't think MOOCs are sufficient, as is, for students to receive credit". This is a contradiction, since these universities are at the same time offering several MOOCs.

Apparently, MOOCs allows people all over the world to engage in lifelong quality learning with the only condition of having Internet access. Nevertheless, Liyanagunawardena [15] and Teng [16] point out that learners from different countries confront cross-cultural and linguistic challenges.

Currently, course content produced for teachers of universities offering MOOCs are culturally bound and need to be revisited to meet local cultural needs of international students. Laplante [14] reports that "MOOCs are offered to a global audience of culturally diverse people, which implies certain considerations, like making forum discussions inclusive for all participants. (..) Participants from various locations may not understand the colloquial language and idioms used in discussion forums. (..) Given that people from different cultures are engaging in the dialogue, the likelihood of conflict and misinterpretations are high". Olaniran [17] remarks that "differences in cultures are not easily reconciled, and sometimes, the imagined cultural differences create psychological barriers that can be just as real as physical geographic boundaries." Including cross-cultural considerations in MOOCs will augment their global and democratic educational potential.

Since English is the main language currently used in MOOCs, students with other native languages have difficulties related to their proficiency in English. Olaniran [17] states that non-native speakers read at slower speed than native speakers. For instance, Chinese-English bilinguals read English at 255 words per minute compared to Chinese at 380 words per minute. The speed difference leads to information overload and cognitive issues. Selinger, cited by Olaniran [17], notes that even when content is translated, there are different variations in languages. For instance, Cisco provided the French and Spanish versions of its e-learning course. Unfortunately, the French version was in the Canadian French, while the Spanish version used the South American Spanish, both of which differ from their European versions, hence, creating problems for students from France and Spain. The language barrier discourages many potential users of MOOCs.

The openness and massiveness of the MOOCs implies that instructors, teacher assistants, and students come from diverse cultures and speak different native languages, which raise specific challenges regarding accessibility. Hence, cultural background and language barriers have to be taken into account when choosing contents, examples, and learning activities which might be unfamiliar or even offensive to certain learners.

Also, user interfaces require special adaptations to make them accessible for non-native speakers. Dunn et.al, cited by Olaniran [17], points to color issues related to culture: "For instance, when giving feedback to learners in some East-Asian cultures, the use of red color is considered inappropriate since red is good luck color, unlike in Western culture where it suggests errors. Similarly, they caution against the use of white color when designing an entry web page for Japanese students, because in Japan white is the color symbol of mourning. (..) The physical world of learners needs to coincide with tools, signs, and symbols of the e-learning world. (..) Simple visual materials such as icons, sounds, and menu can be replaced by local word or sign." An example of a cultural-bounded symbol is the International Committee of the Red Cross (ICRC) emblem. The red cross is viewed as pro-Christian, so the ICRC created the red crescent moon, which is in turn viewed as pro-Muslim. Ultimately, ICRC decided to implement the red crystal, which is totally secular.

4 ACCESSIBILITY

The International Organization for Standardization (ISO) defines accessibility as “the usability of a product, service, environment or facility by people with the widest range of capabilities” [18]. Tim Berners-Lee, inventor of the web, stated in 1999 that “accessibility is the art of ensuring that, to as large an extent as possible, facilities (such as, for example, web access) are available to people whether or not they have impairments of one sort or another” [19].The World Wide Web Consortium (W3C), organization in charge of developing web standards, created the Web Accessibility Initiative (WAI) to develop guidelines for universal access. In 1999, WAI published the Web Content Accessibility Guidelines 1.0 (WCAG 1.0). In 2008, accessibility experts and disabled users made corrections and extensions that led to WCAG 2.0. In 2012, ISO recognized WCAG 2.0 as an international standard, named ISO/IEC 40500:2012. Countries such as U.S. and Spain reference WCAG 1.0 or 2.0 in their accessibility laws.

WCAG 2.0 [20] establishes four principles that give the foundation of web accessibility: Perceivable, Operable, Understandable, and Robust, known as POUR. The perceivable principle states that users must be able to perceive with their able senses both the content and the user interface. The operable principle states that users must be able to operate the interface through interaction that the users can perform. The understandable principle states that users must be able to understand the content as well as the operation of the user interface. The robust principle states that users must be able to access the content as technologies advance.

Under WCAG principles, there are 12 guidelines and 61 requirements of web accessibility, called success criteria. Requirements belonging to level of conformance A must be satisfied to make the content accessible for all users. Requirements from level AA should be satisfied to remove the accessibility barriers. Requirements from level AAA may be satisfied to make the web content more comfortable for different groups of users. According to W3C-WAI [20]: “Following these guidelines will make content accessible to a wider range of people with disabilities. (..) And will also often make web content more usable to users in general.” Creating course content and interface around accessibility regardless of student demographics is especially important for MOOCs [21].

5 FLIPPING CLASSROOM APPROACH

The idea of the flipping classroom approach is to invert the traditional order in the execution of a course, which is, first students go to class to attend a lecture and then students proceed to do related homework. In flipping classroom, students first access the video lecture and supporting material online, and then go to class to gather with other students and their teacher to discuss the lecture, solve doubts, do lab exercises and take assessments. The lectures and materials could come from a MOOC that complements the regular classes [22].

Inside Higher Ed [23] reports that “U.S. San Jose State University uses EdX material only to supplement the classroom experience. Enrolled students are expected to review EdX material before they come to class. Faculty, in turn, have more class time to work with students.” In 2012, the course “Introduction to Circuits Analysis” used EdX's “Circuits and Electronics” and had a pass rate of 91%. The same course in conventional format had pass rates as low as 55% [24]. Nevertheless, the high pass rates could obey to other factors besides the flipping classroom approach, such as novelty and motivation.

6 ENGINEERING PROGRAMS AT NATIONAL POLYTECHNIC SCHOOL

The National Polytechnic School (EPN) is a higher education institution with 140 years of existence, engaged in its mission to contribute to the sustainable development of Ecuador. Being a public university, EPN has a social responsibility to prepare engineers that come from low and medium income strata of the population. EPN has 450 faculty members and almost 10,000 students. In 2009, EPN was accredited as first place of the category "A" among Ecuadorian universities. The “Performance Evaluation Report of the Higher Education Institutions of Ecuador” [25] highlights the role of EPN stating: "The results of the analysis distinguish unambiguously the performance of two universities, which not only stand out from the other institutions of higher education, but even in its category, which is why they are on the top. These institutions are the National Polytechnic School and the Coast Polytechnic School."

In the period 2009-2012, EPN reformed the curriculum of its 15 engineering programs. Additionally, the syllabuses of all the common courses from the areas of Basic Sciences, Social Sciences, and English as a Second Language were updated. As a consequence of this reform, currently the curricula of all the engineering programs include an elective subject of three credits that can be freely chosen from the general course offer of the university independently of their major. The idea is to expand the options of elective subjects the students can choose from lists of selected MOOCs hosted in platforms such as Coursera, Udacity, and EdX. This proposal is well aligned with the principle of the EPN Pedagogical Model [26]: "To privilege the leading role of students in their own learning, with the support of teachers as facilitators".

The goal is to institutionalize the use of MOOCs in the 15 engineering programs. We used as study case the Systems Engineering undergraduate program. Fig. 1 shows a section of the Systems Engineering curricula. The three-credit elective subject which is going to use a MOOC is called "Optativa de Libre Elección" ("Free Choice Elective") and belongs to the third semester. The total of credits students have to earn is 248. From these, 48 credits are from Basic Sciences, marked in yellow; 4 credits are from Social Sciences, marked in red; 146 credits are professional subjects, marked in blue; and 30 credits are elective subjects, marked in green.

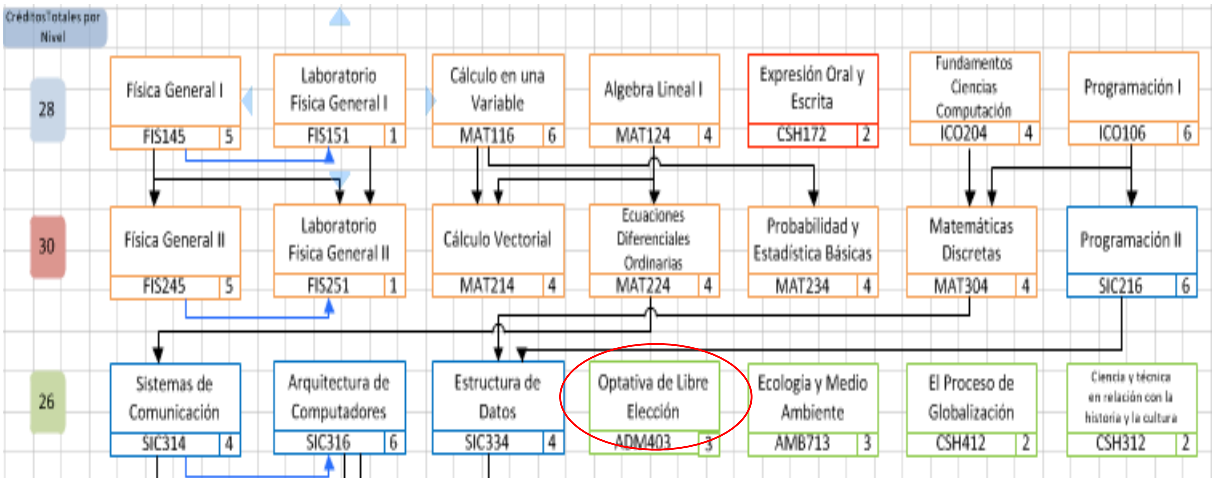

Fig. 1. Free Choice Elective at EPN System Engineering Program

7 REQUIREMENTS

7.1 Generic requirements

The following eight generic requirements are based in EPN normative, organizational culture, and lessons learned from similar experiences in other countries:

1. Teachers receive training in the flipping classroom approach and the use of MOOCs.
2. National Polytechnic School Academic Council supports the use of MOOCs in the context of the Free Choice Elective course present in all the engineering programs curricula.
3. Teachers participate as facilitators of the MOOC local study groups.
4. Students have sufficiency in English as a Second Language (ESL) granted by EPN Languages Centre, if the MOOC associated to their Free Choice Elective is in English.
5. Students attend to face-to-face flipping classes of the MOOC local study group.
6. Students take a mid-course exam and a final exam locally. According to normative, they need to get two grades 7.0 or above to pass the Free Choice Elective and get three credits.
7. Combined flipping classes and MOOC coursework equals to 96 hours of student work during a semester, since according to normative, one credit corresponds to 32 hours of student work.

7.2 Accessibility requirements

Regarding online courses accessibility requirements, Kelly [27] states: "Accessibility is primarily about people and not about technologies. To provide accessible online learning experiences it is necessary to take into account the individual's specific needs, institutional factors, the subject discipline and the broader cultural and political factors. The guidelines developed by W3C-WAI should form part of a broader approach to the provision of accessible e-learning resources". Tables 1 to 3 list accessibility requirements for the specific needs of non-native speakers, organized under the first three principles of WCAG 2.0. The robust principle doesn't apply because is primarily directed to web authors who develop their own user interface components with the purpose to make interfaces understandable to assistive technology. Table 4 shows additional accessibility requirements that cover aspects not considered by WCAG.

Table 1. WCAG 2.0 Perceivable Accessibility Requirements for Non-native Speakers

No	Requi-rement	Le-vel	Description	Rationale
1	1.2.1	A	Alternative media for video content	Non-native speakers benefit from reading documents, presentations or scripts as alternative to watching video lectures in a second language. The alternative material should be in the original language or the correct version of the native language.
2	1.2.2	A	Captions	Non-native speakers find useful to read captions while watching video lectures in a second language. Preferentially, the captions should be in the correct version of the native language.
3	1.2.3	AA	Audio description for video content	The audio description helps the non-native speaker to have a better understanding of video lectures. This audio description should be in the correct version of the native language.
4	1.4.2	A	Pause, stop and control volume of audio content	Non-native speakers find useful to pause, stop and control volume of audio content because they might have difficulty focusing on visual content (including text) when audio is playing.
5	1.4.6	AAA	Background audio	Non-native speakers benefits from listening to video lectures without background audio.

Table 2. WCAG 2.0 Operable Accessibility Requirements for Non-native Speakers

No	Requi-rement	Le-vel	Description	Rationale
6	2.2.1	A	Timing Adjustable	Non-native speakers find useful to turn off, adjust and extend time limits set by the content. This guideline has an explicit exception for time-based testing.
7	2.2.3	AA	Pause of moving content	Non-native speakers find useful to pause content (including text) that is moving, blinking, scrolling or auto-updating. They might have difficulty focusing on visual content.

Table 3. WCAG 2.0 Understandable Accessibility Requirements for Non-native Speakers

No	Requi- rement	Le- vel	Description	Rationale
8	3.1.3	AAA	Definition of unusual words or phrases	It is useful for non-native speakers to have access to the definition of words or phrases used in an unusual or restricted way, including idioms and jargon.
9	3.1.4	AAA	Meaning of abbreviations	It is useful for non-native speakers to have access to the meaning of abbreviations.
10	3.1.5	AAA	Reading level	It is easier for non-native speakers to have access to supplemental content or alternative versions in the native language with a simplified reading level.
11	3.1.6	AAA	Pronunciation	It is useful for non-native speakers to have a mechanism for checking pronunciation when meaning is compromised.
12	3.2.3	AA	Consistent navigation	Non-native speakers benefit from navigational mechanisms that occur in the same order each time they are repeated.
13	3.2.4	AA	Consistent identification	Non-native speakers benefit from consistent identification of interface components that have the same functionality.
14	3.3.1	A	Error identification	It is useful for non-native speakers to have input errors automatically detected, and the item in error pointed out.
15	3.3.2	A	Error suggestion	It is useful for non-native speakers to get suggestions for correcting an input error.
16	3.3.5	AAA	Context-sensitive help	Non-native speakers benefit from content sensitive help when filling out quizzes and participate in discussion forums.
17	3.3.6	AAA	Error prevention	It is useful for non-native speakers to have a mechanism to review, confirm, and correct input before submitting quizzes.

Table 4. Non-WCAG Accessibility Requirements for Non-native Speakers

No	Description	Rationale
18	Speed of video content	Non-native speakers find useful to pause and control the speed of the video lectures. This requirement complements WCAG 1.4.2.
19	Video content duration	Non-native speakers benefit of video lectures not longer than 10 minutes.
20	Time limit setting	Non-native speakers might ask the MOOC teacher for adjustments in the time limit for quizzes. This requirement complements WCAG 2.2.1.
21	Language setting	Non-native speakers benefit from setting the default language used at their MOOC interface. This requirement complements WCAG 3.1.1 which is not included in Table 3 because it refers to programmatically set the language.
22	Glossary	It is useful for non-native speakers to have access to a specialized glossary of terms from the MOOC field of knowledge, in the correct version of their native language. This requirement complements WCAG 3.1.3.

23	Progress	It is useful for non-native speakers that the MOOC indicates lectures taken, coursework finished, coursework failed to submit on time, and upcoming deadlines for pendent coursework
24	Workload	It is useful for non-native speakers that the MOOC indicates the estimated time student should commit to the course each week, as well as the estimated time for doing coursework considering level of proficiency in the second-language.
25	Mobile access	MOOCs used as complement to face-to-face classes should have the alternative to download course content to mobile devices.
26	Permanently available	MOOCs used as complement to face-to-face classes should have a version permanently available with no synchronous due dates for starting the course or submitting coursework.
27	Collaborative translation	MOOCs platform should have a mechanism to allow collaborative translation of course content and discussion forums entries to the correct version of the student's native languages.
28	Cross-cultural	MOOCs interface, content and course work should use colors, signs, words, and sounds acceptable in different cultural backgrounds.

The accessibility requirements alone don't guarantee a good level of accessibility. We need a method that helps implement and comply with the requirements defined. Below are outlined the main steps of the proposed implementation method for using MOOCs as creditable courses.

1. Select a scenario of use from three alternatives:
   1.1. Flipped classroom that use all the sections of a MOOC.
   1.2. Flipped classroom that use certain sections of a MOOC.
   1.3. Flipped classroom that use certain sections of several MOOCs.
2. Select a MOOC or MOOCs that best comply with generic requirement #7 and the 28 accessibility requirements.
3. Select the sections of the MOOC or MOOCs that best comply with the accessibility requirements.
4. Select a semester for the pilot that complies with generic requirement #1.
5. Select a teacher for facilitating the pilot that complies with generic requirements #2 and #3.
6. Select a group of students that best complies with generic requirement #4.
7. Teacher and students enrolls to the selected MOOC or MOOCs and take the selected sections according to generic requirements #5, #6 and #7.
8. Teacher and students gathers data and provide feedback to improve the proposal
9. Teacher evaluate learning outcomes

Mechanisms for steps 5, 6 and 9 are yet to be defined. The first steps of the outlined method had been applied in our study case of the System Engineering program:

1. The scenario of use selected is flipped classroom that use certain sections of a MOOC.
2. The MOOC selected is Udacity's “Introduction to Computer Science.” This MOOC complies with enough WCAG and non-WCAG accessibility requirements.
3. The sections selected are Lessons 1 to 7.
4. The pilot will take place in the first semester of 2014.

Steps 5 to 9 hasn't been performed yet. The case study will help to validate the generic requirements, the accessibility requirements, and the implementation method.

8 CONCLUSIONS

MOOCs are supposed to able people to engage in lifelong quality learning with the only condition of having Internet access. Unfortunately, learners from different countries confront cross-cultural and linguistic accessibility challenges when using MOOCs.

We defined seven generic requirements to consider MOOCs as creditable courses. Of a total of 61 requirements of web accessibility defined by WCAG 2.0, this research identified 17 relevant for improving the accessibility of MOOCs for non-native speakers. From these, 6 corresponds to level A, 4 to level AA, and 7 to level AAA.

We defined eleven non-WCAG accessibility requirements relevant for non-native speakers that point out linguistic and cross-cultural considerations for MOOCs content, interface and coursework.

Accessibility requirements alone can't guarantee a good level of accessibility. We need a method that helps implement and comply with the requirements defined. We outlined the main steps of the implementation method for using MOOCs as creditable courses.

Although the curriculum content of a course may be globally acceptable, the process to achieve learning outcomes requires culture specificity and need to be evaluated. This is probably the most challenging aspect of implementing this proposal.

Future research is needed in the following topics: flipping classroom approach mixed with the use of MOOCs, cultural bound learning styles in MOOC settings, use of assistive technologies such as on-the-fly translators.

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