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Article

Massive Online Open Courses: Features for Understanding and Learning

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Abstract: Massive Online Open Courses (MOOCs) are based on digital cognitive technologies that serve the education of the greatest number by promoting understanding and learning. Combined with appropriate functionalities, methods, and procedures, MOOCs may become Smart Things with intelligent devices at the service of learners. This article aims to introduce to the education community a method for defining and evaluating the exemplary nature of MOOCs as Smart Things that have a user-centric design based on utility, acceptability, accessibility, usability, and ergonomic criteria. The procedure implemented in the following three-phase study is a Human Centered Design based co-construction of an exemplary MOOC for user-learners and designers. In the first phase, a brainstorming study is carried out to define the exemplary MOOC as a Smart Thing by collecting and establishing indicators according to their contribution to the exemplary MOOC. In the second phase, the construction of evaluation tools is studied to assess the exemplary nature of the MOOC by testing 29 indicators and their weights. The third phase is for a focus group study about the evaluation of the learnability of MOOCs produced by learners and designers' cooperation. The results of the study lead to a series of recommendations aimed at promoting the design of exemplary MOOCs.

Keywords: Smart things for Education, Digital learning, Cognitive ergonomics, MOOC's accessibility and usability

1. Introduction

Massive Online Open Courses (MOOCs) become increasingly popular as mass learning tools around the world. In 2020, the use of MOOCs was accelerated with the Covid-19 pandemic, passing the milestone of more than 180 million registered worldwide outside of China. Accessible to everyone on the internet, sometimes free, and provided by universities (950 universities in 2020) for the most part, MOOCs have given rise to new ways of understanding and learning (Bylieva et al., 2020) and brought thousands of learners together (Shah, 2020). For example, one of these online courses attracted 300,000 users (Karsenti, 2013).

In order to improve the pedagogical and didactical qualities of MOOCs, this study was carried out for defining and evaluating the exemplary nature of MOOCs which is defined as the quality of "serving as a desirable model or being very good". An exemplary MOOC can be thought of as "ideal" as it fits the criteria for optimized understanding and learning and meets the needs of each of its target users. Exemplarity is the concept of an ideal and universal theoretical model of MOOCs, fulfilling the goal of quality and serving as a reference for the design and evaluation of any particular MOOC.

Designing Human Computer Interaction (HCI) is a difficult task. As a consequence, the operation and the user interface of HCI have to be as simple as possible. Don Norman identified "seven principles for transforming difficult tasks into simple ones" as follows (Norman 2013): (i) Using knowledge in the world and in the head, (ii) simplifying the task structure of the tasks, (iii) making things visible and bridging the gulf between execution and evaluation, (iv) obtaining the mappings right, (v) exploiting the power of constraints, both natural and artificial, (vi) designing for human error, and (vii) standardizing when all else fails. As

such a user-centric approach is a starting point for defining the exemplary nature of a MOOC (Erkmann et al., 2019), the three-phase study presented in this article exposes the methods of co-construction by user-learners and MOOC designers of the ideality of any particular MOOC.

The main question of this study is how to design a MOOC that is best suited to user needs, offering optimal learning and understanding of the content to be displayed for teaching-learning. To answer this question, it is necessary to define what is the targeted MOOCs and observe their uses according to the objectives of the learners, as well as those of the designers, and check how they coordinate for utility, acceptability, accessibility, learnability of the MOOC's content for learnability of users' procedures and ultimately for usability. For the goal of improving the quality and exemplary nature of MOOCs, 10 MOOCs were selected based on the observation that users are not fully satisfied with existing MOOCs. the results are expected to help improve the quality of the present MOOCs.

The objective of a MOOC user is the validation of a new way of teaching-learning optimized by the quality of the transmission of knowledge, the quality of the interaction (Dai et al., 2020; Galikyan et al., 2021), social presence (Zou et al., 2021) as well as by the management of the learner's time (de Barba et al., 2020). However, objections to the quality of MOOCs concern (i) its utility when the MOOC does not meet users' various expectations (from personal enrichment to the acquisition of technical know-how) and (ii) accessibility since, most often, the MOOC is not accessible to people with disabilities, or is not ergonomic for general users in addition to lacking attractiveness for users′ motivation.

A MOOC designer, therefore, needs to promote the achievement of the new way of teaching-learning by taking into account the following MOOC's technological constraints. (i) lnternet speeds and digital media available to learners are variable, (ii) the course is exclusively given online through videos and textual documents (in downloadable or non-downloadable media), (iii) some MOOCs can be performed live, including videos already performed, (iv) exercises performed and graded online, and (v) an unlimited number of learners. The objectives for designers then seem diverse. For them, it is a question of designing exemplary MOOCs from the point of view of perceptual, motor, and cognitive accessibility techniques. The first condition to be satisfied is that the MOOC is adapted to people with disabilities, which requires an interface adapted to its users (Barcenilla et al., 2013). With this condition satisfied, the MOOC must be usable, intuitive, and understandable. It must be attractive, motivating, and useful for conveying knowledge and meeting the knowledge needs of learners.

Based on ISO 9241-210 (ISO / TC 159 / SC 4 Ergonomics of human/system interaction, 2010) and ISO13407, which mainly recommend two user-centered approaches (user tests and expert evaluation) and considering the guidelines or the usability and accessibility requirements of the literature (Brown and Paulus, 2002), we carried out this study which fell under the Human Centered Design (HCD) approach of MOOCs ergonomic conception and evaluation (Nielsen, 1994; Vian et al., 2009; Norman, 2013; Meyer and Norman, 2020; Soares, 2021).

The three-phase study has the following three steps of a whole HCD research on how to produce a quality MOOC, named an exemplary MOOC.

The first phase is to define what an exemplary MOOC is from the point of view of MOOCs designers and users by collecting the dimensional attributes of this quality. The second phase is to build the evaluation tools to measure the MOOC degree of exemplarity. The third step is to improve any existing MOOC through an iterative loop that comprises the users' evaluation of its exemplarity degree by its users followed by recommendations about how to increase the MOOC's quality. This study is to develop tools for evaluating existing MOOCs (questionnaire) and producing future MOOCs (recommendations) under the concept of the ideal MOOC.

The first phase includes brainstorming sessions for the collection of indicators of the ideal MOOC according to general teachers, designers, and users' needs. The second phase is to build up the questionnaire as a tool to measure the exemplary nature of any given MOOC, and the last phase is to evaluate existing MOOCs by present users as focus groups. The outcomes of this phase make it possible to produce a series of recommendations for MOOC designers.

2. Materials and Methods

2.1. Improving MOOC User's experience : What Is Already Known

The user experience of MOOCs has been studied in various literature. For instance, the user experience of platforms dedicated to MOOCs was investigated for learners, and meta-analysis has been published (Almatrafi and Johri, 2018; Deng and Benckendorff, 2021). The result included (i) categories of learners and of learning (Koller et al., 2013; Chang et al., 2015), (ii) motivation and acceptance of MOOCs technologies (Romero-Frías et al., 2020), (iii) participation as a success factor (Phan et al., 2016; Yang et al., 2017), (iv) the effect of "Flow" as defined by Nakamura and Csikszentmihalyi (2014), the interest shown in the MOOC and participants' satisfaction (Lu et al., 2019) and, finally, (v) the perception of the quality of a MOOC (Dai et al., 2020) with (vi) as the success factors of a MOOC (Kay, 2013; Armellini et al., 2016; Lu et al., 2017; Azevedo and Marques, 2017; Feng et al., 2018). The last two dimensions corresponded to those of exemplarity (the quality of serving as a desirable model or being very good). The previous results recommended that teacher-designers use MOOCs (Conole, 2013) for improving the learning experience (Deng and Benckendorff, 2021).

2.2. Increasing Exemplary Nature of a MOOC

Specifying the quality of a MOOC was carried out with the French Digital Platform (FDP) for MOOCs (*France Université Numérique, FUN*) as part of a research project titled "*Expérience Innovante sur FUN pour des Formations En Ligne accessibles*" (Eiffel-a) which means "*Innovative Experience on FDP for Accessible Online Training*". Centered on the exemplarity/quality of a MOOC, a particular emphasis is put on the ergonomic dimensions that support, promote, and enhance learning (Lachaud et al., 2018).

Including computer science and cognitive technologies, the information and communication technologies (ICT) to support blended learning as well as the realization of Massive Online Open Courses (MOOCs) change the MOOC's exemplary quality of distant teaching-learning interaction. The Human Centered Design (HCD) based approach was adopted to elaborate a general and practical method and extract and evaluate the qualities of an exemplary MOOC for enhancing the MOOCs ergonomic conception and evaluation in this study.

The elaboration and intervention for the rational conception and evaluation of exemplary MOOCs are as follows.

(1) First of all, the exemplary nature of a MOOC is operationally defined from the point of view of the cognitive ergonomics quality components (dimension, properties) for teaching and learning: mainly usability and accessibility for all, including people with specific needs according to cognitive, sensory, and/or motor deficits.

(2) Second, a tool is developed for measuring the MOOC quality components of a MOOC as a method of defining indicators of the quality of a MOOC (i) for data collection, (ii) for data processing, and (iii) for interpretation and use of results. In this study, the quality of a MOOC is assessed indirectly from users' subjective experience. The developed measurement tool here is a questionnaire to understand this experience while the MOOCs' quality indicators correspond to the different quality components of the users' experience.

(3) Third, the method with pilot MOOCs is iteratively tested and evaluated to provide objective quantitative and qualitative data about the application of the tools developed in steps (1) and (2).

This Human Centered Design (HCD) based approach confronts MOOCs' teachers, computer science designers, and students with technological proposals and realization at different levels of definition and completeness in the MOOC technical development lifecycle (Kobylanski et al., 2020). Teachers are designing the didactics and pedagogy of the course content as well as exercises to teach, train, and evaluate students about their knowledge and know-how. Computer Scientists are programming how MOOCs are run on the dedicated platform. From the didactics and pedagogy design, commands, and operations in algorithms, they implement

the platform with contents, exercises, and functions to enhance the teaching-learning interaction, that is, a number of MOOC enrichments. Learners are the users that finally discover and learn in the MOOC as a cognitive tool for learning.

Thus, teachers, computer science designers, and students need to define the values and criteria of MOOC quality (step 1) as the ideal and exemplarity of the eLearning platform. Defining the underlying dimensions and properties of quality can then be used as indicators of satisfaction with MOOC eLearning content (step 2). Then, a method is tested and assessed with MOOCs as experimental materials (step 3).

MOOCs are based on technologies for learning including existing technologies and innovations to improve MOOC quality for teaching-learning. Within the Eiffel-a project, as things progressed, the following technical innovations are conceived to improve MOOC exemplarity.

(1) Video enhancements (*interactive chaptering integrated into the video Transcription/subtitling/translation of videos*), Media enhancements (*interactive geographic maps in videos, sections dedicated to geographical maps*)
(2) Accessibility of MOOC content (*accessibility of geographic maps, audio description, accessibility, and guide page*)
(3) Interaction enhancements (*skipping introduction of the videos at will, opening a description at any time, opening a video in a video, jumping or redirection to other parts of the video course, opening quizzes in the video*)
(4) Learning technologies (*memory anchoring; right time exercises in the dashboard and the course, feedback for memory anchor questions*)
(5) Live events for teacher-to-learners, and learners-to-learners interactions (*automatic login to live lessons, within the direct: automatic chat translation and sharing of documents…, design of live elements, role play activity*)

The ICT-HCD method is also intended to evaluate MOOCs technologies on how much a given technology improves or impairs the users' experience and how to rightly design, correct, and calibrate a technology to improve MOOC exemplarity.

2.3. Introducing three-phase studies

The first phase study is intended to define the dimensions and properties of an exemplary MOOC. The goal is to produce evaluation indicators for MOOCs assessment. The second-phase study is about the build-up of a set of evaluation items for exemplary MOOC assessment by users. For the ICT-HCD method, users define how to evaluate a MOOC. The tool to create is a ready-to-use questionnaire to measure the level of exemplarity of a MOOC from the users' point of view. The third-phase study is for a "Focus group" to evaluate MOOCs by using the assessment tool. This last interventional step for MOOC users consisted of evaluating existing MOOCs and improving them through an iterative loop. The results of the study lead to the creation of an exemplary evaluation tool in the form of a checklist for teachers and computer science designers to evaluate the level of exemplarity of the MOOC they are presently building up. Within the Eiffel-a project, the developed conceptual and methodological tools were applied to 10 various MOOCs.

3. Phase 1: Defining an exemplary MOOC

3.1. Rationales

The first-phase study consists of brainstormings about the qualities of a MOOC. The objective is to produce indicators for assessing the exemplary nature of a MOOC by collecting dimensions (*e.g., learnability: easy to learn*) and properties (*indicate what are the important notions*) of user needs. The principle of brainstorming is to make ideas visible to all participants for facilitating divergent thinking, i.e. the generation of associations around the concerned issue (Brown and Paulus, 2002). The objective of the brainstorming sessions is to collect as many different ideas as possible about the quality criteria of MOOCs. These ideas are analyzed and incorporated into the criteria grid under development.

3.2. Method

3.2.1. Participants

The Brainstorming study involved 21 participants: 8 MOOCs teacher-designers, 8 student-users (6 of them without specific needs, 1 blind student, and 1 with diverse disabilities), and 5 accessibility specialists working with people with specific needs. Following the rules of research ethics to ensure a fully informed understanding of the implications of participation, each participant signed informed consent before they participated in the study with an explanation of the scope, objectives, and a guarantee of the anonymity of the collected data.

3.2.2. Materials and procedure

Two brainstorms were carried out for collecting verbal data relating to the criteria of the quality of a MOOC. The first brainstorming was for teacher-designers and student-users, while the second was for accessibility specialists. The two sessions took place in the LUTIN platform laboratory in Paris. Each brainstorming session was managed by a facilitator who was assisted by a person collecting the post-its and a co-facilitator who displayed them on the board while organizing them semantically. People with disabilities in writing were accompanied by a person to transcribe their ideas. The role of the session leader was to present and explain the topic (*how will you describe a perfect and exemplary MOOC? For your best learning experience?* "*What is an exemplary MOOC in terms of accessibility?*) as well as the rules of expressing own ideas in turn for the group (*free expression, lack of judgment, any idea is announced aloud then transcribed on a post-it, to explain own ideas, to discuss and complete others' ideas*) while the experimenters facilitated the production of ideas by the group (relaunching when necessary; e.g., "*What do you think determines the quality of a MOOC?*") and to systematically synthesize the ideas produced for each topic. During brainstorming sessions, participants were encouraged to express themselves in turn about the key issues of the exemplarity/quality of a MOOC provided by other participants. The duration of the brainstorming session lasted approximately one and a half hours.

3.3. Results

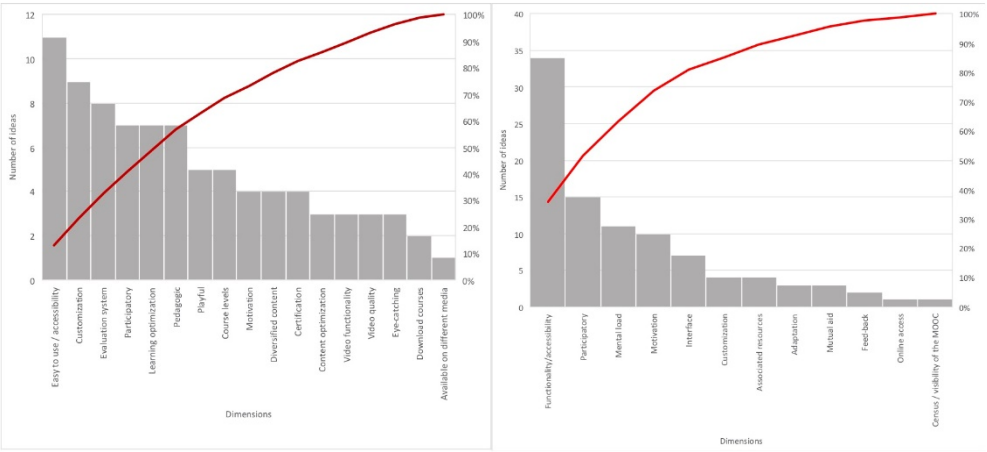
There were main differences in the occurrences of dimensions between the results of the first brainstorming with teacher-designers and student-users, and the results with accessibility specialists. The total number of semantically distinct ideas was 86 among teacher-MOOC designers and student-MOOC users (brainstorming 1) and 95 among accessibility specialists (brainstorming 2). The collected ideas were categorized and grouped into semantic dimensions. 4 dimensions with 16 sub-categories were extracted to determine the quality of a MOOC. Each dimension corresponded to one of the 4 criteria determining the quality of a MOOC (Table 1).

Table 1. Criteria from the brainstorming session.

Number	Criteria
1	Ontology
2	Ergonomics
a	Utility
b	Perceptive accessibility
c	Acceptability
d	Ergonomic accessibility
e	Learnability
f	Usability
3	Pedagogy

	a	Motivation
	b	Customization
	c	Feed-back
	d	Associated ressources
	e	Leaning optimization
	f	Participatory aspect
	g	Evaluation
	h	Certification
4		Technology
	a	Video/Image
	b	Audio

Brainstorming 1 highlighted 17 properties of an exemplary MOOC, the main one of which is "*easy to use for accessibility*" (11/86 ideas). To obtain the described exemplary MOOC, other dimensions such as "*Customization*", "*Learning evaluation system*", "*Participatory*" and "*Pedagogic*" (Fig. 1(a)) were considered. Brainstorming 2 highlighted 12 properties of an exemplary MOOC, and the main one was " *Functional features for accessibility* " (34/95 ideas). Other properties included "P*articipatory*" and "*Mental load*" (Fig. 1(b)).



(a) (b)

Figure 1. Collected properties of an exemplary MOOC ordered according to their importance (number of related collected ideas). For teachers-designers of Brainstorming 1 (a): *Easy to use/accessibility, Customization, Evaluation system, Participatory, Learning optimization, Pedagogic, Playful, Course levels, Motivation, Diversified content, Certification, Content optimization, Video functionality, Video quality, Eye-catching, Download courses and Available on different media*. For accessibility specialists of Brainstorming 1 (b): *Functionality for accessibility, Participatory, Mental load, Motivation, Interface, Customization, Associated resources, Adaptation, Mutual aid, Feed-back, Online access, Census/visibility of the MOOC.* The Pareto curve (red) indicates the percentage of cumulative frequencies.

As a supplementary result, a definition of each MOOC-related concept was carried out according to participants' verbatims.

(1) *A quality MOOC* is a MOOC made of videos with good quality sound, light, and image and with dynamic video editing, shot changes, and a format of short shots.

(2) An *educational MOOC* is keeping a weekly rhythm (*that does not publish all the courses at the same time, but week-to-week*), indicating the number of necessary weeks, limiting the evaluation by pairs, and differentiating the type of teaching while recalling the MOOC's objectives (skills acquisition).

(3) A *diverse content MOOC* is offering a variety of educational activities, based on the technology, entertainment, and design (TED) of Storytelling and dealing with both knowledge and know-how.

(4) A *downloadable courses' MOOC* with pdf versions of educational documents and slide shows for download.

(5) An *accessible MOOC* has the same content on different media to be read either on a computer, tablet, or phone (*speech-to-text and text-to-speech*) with both online and offline accessibility.

(6) An *optimized content MOOC* is effective in information and chaptering that presents synthetic content.

(7) A *functional MOOC* contains chaptered videos and allows to quickly switch within a video from one chapter to another and between videos from one video to another.

(8) An *easy-to-learn MOOC* is simple and quick with all of its modules available, essential functionalities, and no other functionalities, allowing intuitive navigation in contents on the go and including a video search engine, voice synthesis, highlighted texts, and a video-to-text transcription.

(9) An *eye-catching MOOC* is dynamic as it includes fast-paced lessons to give off a good first impression with the first videos (decisive for engaging to continue the course).

(10) An *optimizing learning MOOC* has the course in a multilingual version, using different media (images, sounds, words, videos, etc.) for the cognitive redundancy of information, highlighting the training key elements within the video (What), allowing to properly identify the functions (what for) as well as the video player icons used as commands (how), providing multiple choice questions within the course in order to reinvest knowledge (anchoring learning), and offering a course summary at the end of the video.

(11) A *personalized MOOC* allows learners to create a profile for areas of interest, giving access to a learning path (pedagogical progression) with a set of goals matching the learner profile, customizes this function and controls the video player, defines precisely the set of next possible MOOCs based on the history of the learner's account, and makes the learner lead the learning path to rightly choose the next course (above or below the level of the current MOOC) depending on progress made.

(12) A *fun MOOC* is inspiring to make learners want to learn and includes an assessment that neither tenses nor scares.

(13) A *participatory MOOC* is appealing to the community by offering collaborative activities, containing a benevolent and functional forum, offering regular live videos supported by active teachers, and offering peer support via social networks.

(14) A *motivational MOOC* provides feedback on the participants' activities, stating positively student participation and valuing this engagement through the delivery of satisfaction and gratification rewards, allowing to recognize successes.

(15) An *adapted MOOC* adjusts the levels of the proposed courses by clearly, precisely, and simply indicating the conditions and prerequisites for a given course, having trailers demonstrating the content of the course, and indicating how to obtain the knowledge to fulfill the conditions and prerequisites of this MOOC, mainly the courses program.

(16) A *right assessment MOOC* has a system offering an assessment consistent with the videos, formulating reliable and unambiguous questions, allowing self-assessment of skills, having multiple choice questions, testing learners on what should be remembered at the end of courses, and offering an alternative learning path that does not require answering the questionnaires.

(17) A *certified MOOC* offers academic value by differentiating the certification from monitoring and indicating the name of the establishment providing statements of completion and a legal value certification.

4. Phase 2: Evaluating MOOC

4.1. Rationales

Starting with the result of the first-phase study, the second-phase study was carried out to create items to assess existing MOOCs. This study is a continuation of the first-phase study to weigh the indicators that were produced in the first-phase study. The objective of this second-phase study was to carry out a questionnaire to assess the exemplary nature of existing MOOCs.

4.2. Method

4.2.1. Participants

The 21 participants who took part in the brainstorming sessions (the first-phase study) also took part.

4.2.2. Materials and procedure

An evaluation sheet with 54 items was developed from the results of the brainstorming sessions (Table 2). Focus groups were formed to stimulate convergent thinking and focus on the importance of the 54 items (Greenbaum, 1999). Relating to difficulties in understanding the evaluation, the items were evaluated and corrected by the focus group committee. The focus group session was managed by a facilitator who first introduced the criteria. Then, each item was presented to make the participants understand the meanings. Users rated the perceived importance of each item on a 4-point scale (*not important, important, very important, essential*). In case of indecision or comprehension problems, participants could choose not to answer. Three meetings were conducted, each including one of the three populations. The duration of the meeting was about an hour.

4.3. Results

Participants scored 54 items on a scale of 30 points. Teacher-designers had an average score of 20.88 with a standard deviation of 4.1, student-users showed an average score of 23.8 with a standard deviation of 3.93, and specialists in accessibility showed an average score of 20.65, with a standard deviation of 6.44. The average score of each item was then calculated by averaging the results of the three groups of participants (average= 21.78, standard deviation = 3.53). Items with scores over 21.78 were considered to be important.

Table 2. List of 54 items classified from most important to least important indicator according to the average weight of each item (EU = Ergonomics - Utility; E-ACCP = Ergonomics - Acceptability; O = Ontological; E-ACC-P = Ergonomics - Perceptual accessibility; E-APP = Ergonomics - Learnability; E-UT = Ergonomics - Usability; E-ACC_E = Ergonomics - Ergonomic Accessibility).

Dimension	Items	Teachers - designers (n = 8) / 30	Students (n = 6) / 30	Accessibility specialists (n = 5) / 30	Average (N = 19) / 30
E-U	The validation of the Mooc is based, among other things, on meeting the needs of its target audience.	25.00	30.00	30.00	28.33
E-ACCP	The objectives pursued using the MOOC are accepted by the target audience (s).	25.00	30.00	30.00	28.33
E-ACCP	The prerequisites contributing to acceptability, the MOOC indicates them and gives an assessment of the load caused.	28.75	25.00	30.00	27.92

E-U	What is most useful is highlighted. If several target audiences, they have different uses, the distinction is given.	21.67	26.67	30.00	26.11
O	Must exist at a time (duration) and place (link).	20.88	26.67	30.00	25.85
O	Must be available (link).	20.88	26.67	30.00	25.85
E-ACC_P	What to have done AFTER the end of the MOOC is indicated.	20.88	26.67	30.00	25.85
O	Must be available at all times (link).	22.00	25.00	30.00	25.67
E-APP	The evaluation after the end of the MOOC concerns what has been learned but also the MOOC participation in learning.	28.57	28.33	20.00	25.63
E-U	The structure includes the parts and their organization. There is the sequential structure (syntagmatic) of the MOOC, the functional structure (pragmatic: eg, the staging of a teacher who uses resources), and the structure of the content (semantics: the concepts and their organization to explain and transmit knowledge).	20.88	25.00	30.00	25.29
E-ACC_P	What must have been done BEFORE the start of the MOOC for perceptual accessibility is well indicated.	20.00	25.00	30.00	25.00
E-UT	The MOOC has well-defined objectives and a structure of sub-goals (sub-objectives) that promote its use.	20.00	25.00	30.00	25.00
E-ACC_P	Complies with international digital accessibility standards (WCAG2, RGAA3).	20.88	26.67	25.00	24.18
E-APP	The different parties participate in the principles of redundancy and diversity: the structure is not disjointed.	27.5	25.00	20.00	24.17
E-ACC_E	Getting to the MOOC is simple (obvious and inexpensive).	25.71	26.67	20.00	24.13
E-ACC_P	The surface (design, logo, title, appearance, fonts, colors ...) indicates that the MOOC is accessible and how to implement the accessibility tools.	26.25	30.00	15.00	23.75
E-UT	Using the MOOC is simple (obvious and inexpensive).	22.86	28.33	20.00	23.73
O	The learner's cognitive work effort must be appropriate.	21.00	25.00	25.00	23.67
E-U	The surface (design, logo, title, appearance, fonts, colors ...) implicitly indicates WHAT it is and what its uses.	25.71	25.00	20.00	23.57

E-ACC_E	What you need to have done BEFORE the start of the MOOC to participate is well defined.	23.75	26.67	20.00	23.47
E-UT	The course in the structure, the use of the elements and the location are simple.	21.43	28.33	20.00	23.25
E-APP	The surface (design, logo, title, appearance, fonts, colors ...) must participate in the learnability of the content (differentiate, attract attention ...).	26.25	23.33	20.00	23.19
E-ACC_E	The different parts are accessible (e.g. The resources used by the MOOC).	20.00	28.33	20.00	22.78
E-ACC_E	If there are actions to be taken AFTER the end of the MOOC is well defined.	21.43	26.67	20.00	22.7
E-ACC_E	The surface (design, logo, title, appearance, fonts, colors, etc.) must indicate (affordances) how the procedures for use are implemented.	24.29	23.33	20.00	22.54
E-UT	What to do during the MOOC is well defined.	22.5	25.00	20.00	22.5
O	The MOOC is assessed from the perspective of student success; success is understood as the appropriation of the content.	20.00	26.67	20.00	22.22
E-UT	What must have been done BEFORE the start of the MOOC is well defined.	22.86	23.33	20.00	22.06
E-APP	The MOOC has well-defined objectives and a structure of sub-goals (sub-objectives) that promote comprehension and memorization.	18.75	16.67	30.00	21.81
E-ACC_E	The MOOC has good ergonomics which makes it easy to achieve the objectives pursued.	24.29	25.00	15.00	21.43
E-ACCP	Elements of interest to learners are highlighted: "this is for you".	22.5	21.67	20.00	21.39
E-ACC_P	The importance of perceptual accessibility is presented as well as its contributions to "design for all".	18.33	25.00	20.00	21.11
E-ACC_P	Includes a page describing the accessibility level of the MOOC.	20.00	23.33	20.00	21.11
E-APP	Learnability is assessed during the duration of the MOOC.	25.71	16.67	20.00	20.79
O	Must be sufficient and not depend on inaccessible or non-MOOC resources.	20.00	21.67	20.00	20.56
E-ACC_P	Perceptual, attentional and comprehensive accessibility is guaranteed.	21.43	25.00	15.00	20.48
E-ACC_E	What to do DURING the MOOC to continue accessing it is well defined.	17.14	23.33	20.00	20.16

E-UT	What to have done AFTER the end of the MOOC is well defined.	17.14	23.33	20.00	20.16
E-U	If there are choices, their differentiated participation in meeting needs is indicated.	15.00	20.00	25.00	20.00
E-ACCP	The target audience finds that the MOOC is intended for them and agrees to use it.	17.14	21.67	20.00	19.6
O	The educational treatment is effective.	17.00	21.67	20.00	19.56
O	Must form a whole in itself, while being part of a larger whole (spotting).	18.00	25.00	15.00	19.33
E-U	The MOOC is useful to the target audience (define the dimensions of utility: general knowledge, diploma, profession ...).	22.86	20.00	15.00	19.29
O	Must be properly identified so that its audience is informed of its existence, availability, and permanence.	14.00	23.33	20.00	19.11
E-U	The MOOC is based on an assessment of the needs of its target audience.	15.00	21.67	20.00	18.89
E-APP	The MOOC allows the target audience to learn its content.	24.29	30.00	0.00	18.1
O	Educational processing is what makes it possible to adjust cognitive effort.	18.00	20.00	15.00	17.67
E-APP	Since the satisfaction of the prerequisites contributes to learnability, the MOOC recalls them to promote learning.	20.00	16.67	15.00	17.22
E-ACC_P	The different parts are made all the more accessible the more useful they are (e.g. geographical maps, mathematical formulas). Make the structure accessible.	20.00	15.00	15.00	16.67
E-ACC_P	Contains a help page indicating how to use the MOOC and the instructions for use of the various modules available.	20.88	18.33	10.00	16.41
E-ACCP	The surface (design, logo, title, appearance, fonts, colors ...) "speaks" (corresponds) to the target audience to promote docking and acceptability.	20.00	16.67	10.00	15.56
E-U	The usefulness of the MOOC.	13.33	15.00	15.00	14.44
E-ACC_P	If there are actions to be taken DURING the MOOC (e.g., change of mode), these are indicated.	10.00	18.33	15.00	14.44
E-UT	The surface (design, logo, title, appearance, fonts, colors ...) must indicate (affordances) what to do during use.	10.00	21.67	10.00	13.89

5. Phase 3: Evaluating and Increasing Quality of MOOC with Assessment Tool

5.1. Rationales

The Human Centered Design (HCD) approach to MOOCs ergonomic conception and evaluation was for defining the exemplarity of MOOC (the first-phase study), and then criteria and indicators were defined to evaluate MOOCs (the second-phase study). For improving its concept of design, the third-phase study was carried out. The third-phase study consisted of assessing actual videos and integrating users, designers, and specialists in making a given MOOC. The focus group methodology was used in performance testing. This method is appropriate at the stage where detailed design issues need to be resolved and a working model or prototype of the workplace is available (Caplan, 1990). Users (i) first evaluated the particular MOOC according to the 54 indicators assessment tool and (ii) then made recommendations to improve its quality according to the results of the evaluation (*a recommendation might impact more than one of the quality indicators*). (iii) Following and adapting the users' recommendations, the designers of the MOOC improved the quality with the design and the production for a new evaluation.

5.2. Method

5.2.1. Participants

Twenty students participated in the third-phase study. In accordance with research ethics rules, each participant signed informed consent prior to participation in the study which explained the scope of the study, and its objectives and guaranteed the anonymity of the collected data.

5.2.2. Materials and procedure

The particular MOOC to improve was one of the pilot MOOCs of the project. Four focus groups were created with 3 to 6 students in each group. The materials and procedures for each focus group were the same. The participants were greeted by the three presenters. The participants were seated around a "U" shaped table. Each participant had several post-it notes as well as a pen. The focus group moderator announced the progress of the session by showing slides on a screen as visual support for the participants' tasks. The first part of the meeting focused on introducing the pilot MOOC. The moderator showed the participants the different aspects of the MOOC and invited them to express their opinions. The participants had to write their ideas on the post-its (one idea per post-it). A second experimenter collected the post-its and fixed them on a wall, grouping them by theme. Then, using the same procedure, a comparison between the existing MOOC and other MOOCs was made. Participants were invited to express comparative opinions (negative and positive). Subsequently, participants were invited to express their needs and wishes such as "*What would you have liked to find in this MOOC that was not included?*" ", "*What improvements do you think?*", "What functions would you like to use and which will be useless?", ... Then, they discussed and made recommendations scored as "*very important, important, as much as possible*". For the pilot MOOC, this protocol was to collect successive evaluations and recommendations for designers and to verify that the iterative 3-step ergonomic loop improved at each iteration for users' satisfaction.

5.3. Results

First, MOOC designers and MOOC technology providers were satisfied by the evaluation-recommendation report as a justified process of increasing the quality of the MOOC. Second, and importantly, the reports collected from the focus groups helped constitute a list of technical and practical recommendations for MOOC designers to carry out their projects. Five topics for quality improvement were summarized as follows.

- **Topic 1- Recommendations for audio design**

Improving audio **(***a quality audio recording***,** *pleasant and non-redundant sounds or music***,** *harmonized volume of the sound is***, and** *a medium speed speech rate*)

Transposing audio content (*an audio equivalent in videos and exercises, the audio file of the videos for download, and the audio script for download and consultation, and making sure the audio script is accessible and fun to read*)

Promoting sound environment and immersion (*specific and recognizable sounds to announce an event, sounds to illustrate and reinforce the point, and a short and non-redundant jingle at the start of videos*)

- **Topic 2 - Recommendations for the design of the text**

Improving reading comfort (*Making it easier to read the characters displayed, font design for reading long text on the screen, dyslexia-friendly fonts while improving accessibility, and large font size to facilitate access to the MOOC by as many audiences as possible*)

Taking care of visual fatigue (*displaying white texts on a black background, the use of colored backgrounds, avoiding low levels of contrast, black texts on a white background, and moderate brightness level, airy texts, and avoiding long blocks, large lines spacing to promote reading comfort*)

Making the navigation elements more accessible (*navigation elements on which reading elements are affixed are less adaptable to the zoom function than texts. These elements should be enlarged from the outset to include as many audiences as possible*).

Transposing text content (*the content of the text in an audio version for download and consultation, texts in sign language, and accessible audio and LSF versions*)

Promoting the pleasure of reading (*layout, illustrations, colors, simple and clear language, and reader identification*)

- **Topic 3 - Recommendations for images design**

Improving visual comfort (*"relaxing" colors, contrasts between the background and the foreground, images of the correct size, avoiding too small and too large size, and visible on any medium*)

Transposing imaged content (*integrating an equivalence of any imaged content in the form of another sensory modality and audio for instance*).

Promoting visual immersion (*intuitive and understandable pictograms and mixing text and illustrations*).

- **Topic 4 - Recommendations for video design**

Making it easy to understand the structure of the video **(***video with several elements such as visual and sound, interactive elements related to accessibility such as pop-ups, quizzes, player options, closed captioning, etc., and interactive chaptering*).

Facilitating interaction with video (a*llowing users to navigate videos (for example, with an explicit and intuitive timeline; quizzes into the video, in-video pop-ups to direct the user to other videos or to websites, and a video player integrating accessibility options (customizable subtitling, LSF, etc.*))

Promoting immersion (*short videos, careful editing videos, different sensory modalities facilitating user's immersion (music, sounds, colors, sequence of dynamic shots), different routes through the video content depending on the audience, adaptability to the different audiences, and simplified videos in a "novice" route and more complex videos in an "expert" route*).

Promoting attendance (*regularly offering quizzes and evaluations, enough time for users to respond to quizzes and assessments according to their availability, personalizing profiles and paths within the MOOC, gamifying the MOOC by offering fun exercises, exchanges between learners by offering a functional forum and/or a live chat space, and making teachers as available as possible to answer questions and discuss with learners*).

- **Topic 5 - Recommendations for the organization of the course**

Making it easier to start with the MOOC *(self-explanatory titles accompanied by an identifiable and recognizable icon and short and self-explanatory icons)*

Providing access to all interface functions *(quick distinguishing functions, interactive elements on the screen, the use of underlined text by hyperlinks, and selection with several graphic elements*).

Adapting lessons to daily use (*reduced efforts to act and simple manipulations with smaller numbers of steps to perform*)

Sharing information (*multi-user modes to promote exchange between learners and information sharing functions via document downloading, sending, and viewing messages on the platform or social networks*)

Supporting learners in learning (*user manuals or tutorials as an electronic and downloadable manual, illustrative manual with screenshots and short tutorial videos, integration of online help for long-term support, easy access to documents, downloading course materials, and consulting online)*

6. Discussion and Conclusions

The three-phase study presented in this article was implemented and conducted in the Eiffel-a research project with a double objective: to establish a conception and evaluation method for the making of exemplary MOOCs and to apply this quality evaluation method to each of the 10 successively pilot MOOCs developed in four years (Lachaud et al., 2018). The qualification of each MOOC was then carried out by considering its dimensions and properties. According to the list of 54 items as exemplary criteria (the first-phase study), each item was weighted by its importance and evaluated by students, teachers, designers, and accessibility specialists (the second-phase study, Table 2). This qualification attribution (the third-phase study) was done while successively designing and producing each of 10 MOOCs by the participants including students who needed specific help.

Lastly, for each of the 10 MOOCs, students were asked to answer a questionnaire indicating to what extent their needs were met by the MOOC. This method was a field evaluation of the HDC method for MOOCs quality. Improving quality is not only for each OOC but for the whole process of producing exemplary MOOCs. In addition, because MOOCs are based on technologies, inferences were made to understand how much innovation was conceived, developed, and implemented in MOOCs to improve the quality by taking users' recommendations into account. Thus, the increase in quality was associated with each of the technologies used for the design and production of MOOCs. This was done by evaluating (i) the number of criteria for the use of innovative technology tools, (ii) the proportion of the criteria, and (iii) the weights of satisfied criteria.

In summary, for 54 exemplary criteria, within the first year, the number of criteria satisfied with the MOOC technological development was 38 (*70 % of the criteria and 51 % with weights*). Within the second year, the number of satisfied criteria increased to 40 (*74 % of the criteria and 64 % with weights*). Within the third year, this number was 48 (*88 % of the criteria and 76 % with weights*). These year-to-year differences corresponded to an increase in quality, which was statistically significant ($p < 0.01$).

The ICT-HCD method developed in this article was to improve the quality of MOOCs. It can be applied without taking into account the recommendations in previous literature. However, the evaluation of the method and its results verify the ergonomic principles for the usability and the exemplary nature of MOOCs. There were six ergonomic dimensions of the exemplary MOOC in terms of the ergonomic heuristics reported (Nielsen, 1994). Nielsen's first ergonomic heuristic was the "*Visibility of system status*" for the system informing and feeding back to users within a reasonable period. The results showed that this heuristic encompassed the dimensions of "*Easy to use*", "*Functionality", "Accessibility*" and *"Feedback"*.

The notion of "*accessibility*" is also a part of Nielsen's second heuristic which is the "*Matching between the system and the real world*". The system needs the syntactic and paradigmatic forms of similes to facilitate understanding. The "*Mental load*" dimension was mentioned as the heuristic of "*Recognition rather recall*". This is a recommendation to save users' working memory by making objects, actions, and options visible. The "*Interface*" dimension is linked to the heuristic of "*Aesthetic and minimalist design*" which aims to eliminate unimportant or rarely used information from the interface. Finally, the "*Adaptation*" dimension matches the "*Flexibility and efficiency of use*" heuristic, which consists in making the interface suitable for both novice and expert use. The principle of "*Feedback*" is the set of information given to the user to make them understand the results of actions as a new state of the system once these actions have been carried out. The principle of feedback by Norman (2013) is one of the six major ergonomic dimensions. The result of this study showed that this notion was also of importance for the creation of a quality of MOOC. The "*Easy to use*", "*Functionality", "Accessibility*" and *"Feedback"* dimensions are similes to the "*Discoverability", "Affordances" and "Signifiers"* ergonomic principles also described by Norman (2013). The principle of "*Discoverability*" is based on the determination of possible actions, the principle of "*Affordances*" on the existence of appropriate means to make possible the actions of the user, and the principle of "*Signifiers*" on the efficient use of signifiers guaranteeing the "*Discoverability*" and the "*Feedback*". An "*Easy to use*" and accessible MOOC with functionalities needs to adopt the ergonomic principles of "*Discoverability*", "*Affordances*" and "*Signifiers*".

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