Towards Truly Accessible MOOCs for Persons with Cognitive Disabilities: Design and Field Assessment

Pierre-Antoine Cinquin, Pascal Guitton, Hélène Sauzéon

Towards Truly Accessible MOOCs for Persons with Cognitive Disabilities: Design and Field Assessment

Pierre-Antoine Cinquin[1], Pascal Guitton[1] and Hélène Sauzéon[1]

[1] University of Bordeaux & INRIA
FirstName.LastName@u-bordeaux.fr

Abstract

MOOCs are playing an increasingly important role in education systems. Unfortunately, MOOCs are not fully accessible. In this paper, we propose design principles to enhance the accessibility of MOOC players, especially for persons with cognitive disabilities. These principles result from a participatory design process gathering 7 persons with disabilities and 13 expert professionals. They are also inspired by various design approaches (Universal Design for Learning, Instructional Design, Environmental Support). We also detail the creation of a MOOC player offering a set of accessibility features that users can alter according to their needs and capabilities. We used it to teach a MOOC on digital accessibility. Finally, we conducted a field study to assess learning and usability outcomes for persons with cognitive and non-cognitive impairments. Results support the effectiveness of our player for increasing accessibility.

Keywords:

Accessibility, Cognitive disabilities, MOOC, Participatory Design, Ability based design, Usability.

1. INTRODUCTION

Even if the situation of Persons with Disabilities (PWDs) is improving due to inclusion policies aimed at combating discrimination, there are still many areas where disability is somewhat overlooked. This is particularly the case for education: the representation of PWDs decreases drastically between primary school and higher education. Lower qualification leads to adverse consequences in the professional world, where unemployment rates for PWDs are much higher than average.

As online e-learning platforms such as MOOCs (Massive Online Open Courses) are playing an increasingly key part in our education and training systems [1], they could allow PWDs to develop new skills, thus facilitating access to employment. Unfortunately, MOOCs are lacking in terms of accessibility, which contributes to PWD's social exclusion. Even if sensory and motor disabilities are beginning to be considered when designing accessible interfaces, this is rarely the case for cognitive impairments (attention, memory…). Although they are very common, they are often referred to as invisible disabilities because they are not very well-known outside of the family, medical or specialized environment [2].

Our overall goal is to enable the development of MOOCs that are accessible for many different learners, by including as much as possible those with cognitive impairments. The main contributions of this paper are:

1) The design and the implementation of a truly accessible MOOC player based on the pre-existing design principles as well as those from a participatory design, which included both PWDs and (scientific or professional) experts.
2) A field study on the use and efficiency (follow-up measures) of this MOOC player in a "real life" context, *i.e.* a real MOOC that we built and broadcast (5800 registered users coming from 60 countries).

2. RELATED WORK

2.1. Accessibility design approaches

Several design frameworks have specifically addressed cognition-related issues. The most known are: Cognitive Load - Instructional Design [3] which aims to reduce distractive and non-instructional information and promoting opportunities to process target information; Universal Design for Learning [4] that proposes using specialized instructional strategies and compensatory devices like speech-to-text transcribers, and Environmental support for cognition [5] that suggest to reduce the demands and attentional cost of tasks, and spare cognitive functions. Those frameworks are fully compatible with recent advances in accessible computing concepts, such as Ability-based Design [6]. It refocuses the accessibility issue on capability rather than disability to adapt a system to what a person can do. For instance, it recommends the possibility for users to adapt the interface instead of specifically designing an interface for PWDs. As a virtuous circle, these adaptations potentially provide benefits for all users. Edwards [7] has shown that it is not a matter of placing a patch on existing systems, but of offering user-driven change. In a MOOC context, where many different people are involved, we think that it is important to take this approach to give all users the best chance to succeed, regardless of their conditions.

2.2. Accessibility & MOOCs

There has been little research activities on MOOC accessibility [8]. Most of the studies on MOOC accessibility were published after 2013 and focus on physically impaired learners. They are essentially based on the assessment of accessibility in relation to "mainstream" accessibility guidelines (*e.g.*, WCAG 2.0 [9]) and unfortunately they include few or no PWDs in the evaluation [10].

Most of existing MOOCs are not fully accessible. In 2014, Bohnsack and Puhl [11] showed that most MOOC platforms had a lack of correct language markers or accessible design. This study concluded that accessibility was not considered when developing these platforms, effectively excluding PWDs and not fulfilling the claim that MOOCs are open to everyone. In accordance with these results, Iniesto *et al.* [12] used automatic tools, a visual disability simulator and analyzed the educational resources of three Spanish MOOC platforms. They showed that many shortcomings in terms of accessibility (absence of links for navigation, misuse of headings or images without alternative text) prevent PWDs from benefiting from these new educational platforms.

Nevertheless, some projects try to overcome this lack of accessibility. The EU4ALL project [13] provides a framework to satisfy eLearning accessibility needs of higher students by using already existing standards and guidelines to customize presentations of several Learning Management Systems. In a different way, Sánchez-Gordón and Luján-Mora [14] propose a plugin for the OpenEdx platform, which adapts the content of the course according to the learner's preferences, needs and competences following a set of predefined adaptation rules.

Although these two studies illustrate real progress in the design of MOOC systems, shifting from a technology to a human-centered approach. Unfortunately, the authors did not assess their systems with real learner and their progress should perhaps be considered as claims rather than ground truth of effective accessibility. Moreover, it is noteworthy that today, no study actually addressed the MOOC accessibility for cognitive impairments (attention, memory…).

3. DESIGN OF AÏANA, AN ACCESSIBLE MOOC PLAYER

A Participatory Design (PD) process was conducted to define the users' needs in terms of basic and specific accessibility features for Aïana. It consisted in meetings and interviews with 7 students with disabilities (age > 18 years) and 13 expert professionals. PWDs exhibited varied neurodevelopmental diseases or neuropsychological syndromes to be representative of cognitive needs that they encountered. To specifically address the needs of persons relative to their cognitive capabilities, we listed and consigned the successes and requests of PWDs in situations closely related to MOOC experience during interviews. This preparatory phase led to a first set of ideas for accessibility features conceptualized in paper mockups (Iteration Loop 1) then software mockup (Iteration Loop 2) in an iterative process. Finally, ideas selected during these two PD session loops were integrated into a first version of Aïana, our MOOC player. This version was then evaluated during a field study.

3.1. Key design features

In this section, the features from the participatory design sessions are presented. They are organized into two main purposes: self-configuration vs. access.

Self-configuration

Allows users to select the desired streams, and then configure the position and location of their display window and of the buttons of the interface.

- **Separation of streams:** Classically, a MOOC consists of several types of information (video, slides, subtitles) merged together in a single stream (video most often). We built our MOOC using a different principle by explicitly separating all information streams into different windows.
  Goal: Allow the user-selection of the more useful stream for using screen-readers or for optimizing the learning task.
- **Selection of useful streams:** Users can configure their work space in Aïana by selecting which streams they want to watch, read and listen. This choice can be made at any time and can be modified whenever users wish to do so.
  Goal: Enhance task-relevant information, for instance for people for whom few information can be processed such as in cases of cognitive slowing-down or with a decrease of divided-attention or working memory.
- **Spatial organization:** Users can either keep the initial layout as it is when Aïana is first launched, or modify it as they please. They can resize and move each of the control buttons and display windows. These modifications can be made at any time and can be renewed whenever users wish to do so.

Goal: Enhance task-relevant information, for instance to avoid distractors for persons with selective attention deficits or spatial disorders such as in schizophrenia or in attention disorder syndromes.

- **User profile:** By combining these features, users can dynamically configure their own MOOC player to suit their wishes and abilities. These settings form the users' profile. If a user needs evolve due to personal or contextual changes (*e.g.*, MOOC topic, MOOC contents, etc.), then they can reconfigure the player's interface.
  Goal: Promote self-determination perception in users, particularly those related to autonomy as motivational leverage for online e-learning.
- **Social Learning:** Users can save this profile on their computer and therefore to share it, with people who have disabilities close to their own for instance. On a voluntary basis, these exchanges can help create communities of Aïana users, who can exchange and potentially help each other.
  Goal: Promote social interactions and community building, particularly between proficient and less proficient Aïana users.

Access

Allows users to access the stream of information they have selected and navigate through the courseware sequence (start, stop, forwards, backwards, bookmark, *etc.*).

- **Additional Window:** Unfamiliar terms or abbreviations are often explained only once, the first time they occur. We added an information window providing short texts and simple icons. This additional information is intended to assist users in their understanding, for instance by providing the meaning of an abbreviation or by indicating with an alert icon where their attention is required.
  Goal: Externalize non-relevant sub-tasks, for instance for persons with working memory and long-term memory impairments.
- **Time Markers:** To take notes, learners must pause the video, resulting in a stuttered playback of the video which can make course hard to follow. With Aïana, users can put tags on the timeline to mark specific moments of the course so they can quickly and easily access a specific piece of information that they were unable to fully process the first time they play the video.
  Goal: Optimize processing opportunities; for instance, for persons needing specific repetitions or for persons with difficulties for achieving simultaneous tasks (*i.e.*, listen and write) as in the cases of a cognitive slowing-down or attention disorders.
- **Semantic Navigation:** The standard functions for navigating video streams should be enhanced with new features, notably regarding concept-driven navigation in MOOC sessions. In Aïana, the course contents are divided into main instructional units (each containing information which must be considered as a whole to fully understand a given concept) that are presented using one or more slides. It is possible to navigate across the instructional units: users can either return to the previous one in the event of a misunderstanding if they wish to deepen their understanding, or they can move forward if they are already familiar with the current concept.
  Goal: Encourage knowledge use in MOOC navigation, for instance for persons with understanding disorders due to impairments in processing speed, attention working memory, or memory.
- **Different teacher displays:** Classically, teachers are filmed looking into the camera lens forcing users to process simultaneously, but separately, the communication stream uttered by teacher

and the slide’s contents. We proposed a classic frontal face view and a profile view such as the teacher's gaze is oriented to the slide.

Goal: Enhance task-relevant information by supporting joint attention and by avoiding direct face-to-face interaction, for instance for persons with social particularities (such as schizoaffective disorder or autism).

4. FIELD ASSESSMENT

Aïana was used during two sessions of a MOOC dedicated to digital accessibility (5 weeks per session). 651 persons signed the consent form and completed the profile survey (end of week 1) including 94 PWDs (14%). Of these, 146 completed the course and answered all our surveys, including 24 PWDs (19.67%). Among these 24 participants, 8 declared at least one cognitive disability (designated COG group) and 16 declared at least one sensory or motor disability and no cognitive disability (designated NON-COG group). Disability was assessed by a questionnaire derived from the function disabilities taxonomy (sensory, motor/mobility, etc.) according to the International Classification of Functioning, Disability and Health [15]. It included 20 items, of which 8 were about sensorial capabilities, 3 about motor capabilities and 9 about cognitive capabilities (for instance: *I have difficulty reading text, I have difficulty staying focus, I have problems with memorization…*).

4.1. Assessment procedure

To study the impact of Aïana’s features, three outcomes were analyzed:

- **Usability score** using the standardized questionnaire System Usability Scale (SUS) [16]. This questionnaire fits perfectly within an online environment [17].
- **Learning score** by a learning scale using multiple-choice questions. For each course video (each lasting between 2’31 and 10’23, average duration = 6’12) participants were asked to complete an assessment composed of 3 items on average. Each of the 30 assessments was then marked to give a percentage of success. We calculated two scores: once at mid-point (average over the first 14 assessments) and once at the end of the MOOC (average of all assessments).
- **Self-Determination** (SD) scores using a 9 items-rating scale inspired from [18] that assesses the three SD dimensions (Autonomy, Competence and Relatedness). SD is a key factor of technology accessibility and acceptance [19] and of e-learning progress [20], notably for older adults and PWDs [*e.g.*, 21].

4.2. Results

Overall, all learners achieved high learning performance regardless of their disability condition (Table 1). Thus, the functionalities allowed them to access all the instructional material provided through the entire MOOC. Similarly, the Aïana usability results at the end of the MOOC reached a “good” usability level (average of 75) according to Bangor [22]. Before starting the MOOC sessions, we proposed a video-based demonstration and an illustrated user manual as recommended in the field of adoption of assistive technology [23], allowing a good understanding of the offered functionalities amongst learners. Consequently, this video and this manual could have occasion a boost on the subsequent SUS scoring. Furthermore, although group difference failed the significance (p = .607), the mean examination of SUS score reveals that COG (74.75) was slightly more proficient than NON-COG (66.34) until mid-point.

Table 1. Means (and standard deviation) for learning, usability scores (across times: Mid- vs. End-point) and for SD achieved scores according to group condition

		NON-COG	COG
Learning Score (*max. score = .100*)	*Mid-point*	.87 (.08)	.78 (.15)
	End-point	.89 (.08)	.89 (.09)
Usability Score (*max. score = 100*)	*Mid-point*	66.34 (21.53)	74.75 (21.65)
	End-point	75.46 (23.53)	75.81 (13.57)
SD Score (*max. score = 5*)	**Autonomy**	3.46 (.23)	3.94 (.33)
	Competence	3.31 (.24)	3.71 (.34)
	Relatedness	3.20 (.25)	3.04 (.25)

Additionally, Aïana provided a good SD support to PWD needs in terms of autonomy and competence, known as important components for learners' intrinsic motivation. In distance learning, improving the intrinsic motivation of learners (*i.e.*, self-determination) decreases the attrition rate of online learning platforms [24]. This is even truer in the case of PWD, where the lack of accessibility can lead to a bigger effort to self-regulate their learning. Finally, regarding the participation rate, we compare our results to other MOOCs thanks to a recent paper studying eight MOOCs [25]. For the first week, we observed a slightly higher rate of PWD with Aïana (14%) than in other MOOCs (10.75%). At the end of the last week, the difference is much significant: 19.67% with Aïana versus 11.3%. Aïana seemed to make it possible to better keep PWDs throughout the MOOC. This is a promising result that truly accessible MOOC players improve opportunities for the educational inclusion of PWDs.

5. LIMITATIONS AND FUTURE WORK

The user interface of this first version of Aïana has yet to be improved. As already noted, the current version promoted self-configuration according to users' abilities and preferences, but no adaptive features are included, Future works will address this issue to fully cover the principles of the ability-based design. The continuation of the iterative process will also allow us to increase the number of participants and therefore reinforce the statistical results and the diversity of disabilities of potential MOOC users. A tracking log of user's interactions with Aïana is currently under implementation. Its analysis should enable us to highlight the relevance of designed features. .

Regarding the SD scores elicited by Aïana, it would be interesting to think about functionalities that strengthen the relatedness component. In MOOC, the social part is usually handle outside of the courses' material (in a forum or a chat) and it may be interesting to include it directly into the player, mimicking the social presence induced by a classroom. Such new functionalities should be modulated according to user capabilities for cognitively managing additional distractors.

We have successfully designed a MOOC player to support inclusive e-education. Results presented here provide evidence of its good usability value and its positive impact (learning and SD) for PWDs, notably for those with cognitive impairments.

REFERENCES

1. Clark, R. C., & Mayer, R. E. (Eds.). (2016). e-Learning and the Science of Instruction. doi:10.1002/9781119239086
2. Matthews, C. K., & Harrington, N. G. (2000). Invisible disability. In D. O. Braithwaite & T. L. Thompson (Eds.), LEA's communication series. Handbook of communication and people with disabilities: Research and application (pp. 405-421).
3. Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. Learning and Instruction, 4(4), 295–312. doi:10.1016/0959-4752(94)90003-5
4. Rose, D. H., & Meyer, A. (2006). A practical reader in universal design for learning. Harvard Education Press.
5. Morrow, D. G., & Rogers, W. A. (2008). Environmental Support: An Integrative Framework. Human Factors: The Journal of the Human Factors and Ergonomics Society, 50(4), 589–613. doi:10.1518/001872008x312251
6. Wobbrock, J. O., Kane, S. K., Gajos, K. Z., Harada, S., & Froehlich, J. (2011). Ability-Based Design. ACM Transactions on Accessible Computing, 3(3), 1–27. doi:10.1145/1952383.1952384
7. Edwards, A. D. (1995, December). Computers and people with disabilities. In Extra-ordinary human-computer interaction (pp. 19-43). Cambridge University Press.
8. Iniesto, F., & Rodrigo, C. (2016). Strategies for improving the level of accessibility in the design of MOOC-based learning services. 2016 International Symposium on Computers in Education (SIIE). doi:10.1109/siie.2016.7751841
9. Web Content Accessibility Guidelines (WCAG) https://www.w3.org/WAI/intro/wcag
10. Sanchez-Gordon, S., & Luján-Mora, S. (2017). Research challenges in accessible MOOCs: a systematic literature review 2008–2016. Universal Access in the Information Society. doi:10.1007/s10209-017-0531-2
11. Bohnsack, M., & Puhl, S. (2014). Accessibility of MOOCs. Computers Helping People with Special Needs, 141–144. doi:10.1007/978-3-319-08596-8_21
12. Iniesto, F., & Rodrigo, C. (2014). Accessibility assessment of MOOC platforms in Spanish: UNED COMA, COLMENIA and Miriada X. 2014 International Symposium on Computers in Education (SIIE). doi:10.1109/siie.2014.7017724
13. Rodriguez-Ascaso, Roldán, Raffenne, Buendía, Boticario, Montandon, & Santos. (2012). Accessible Lifelong Learning at Higher Education: Outcomes and Lessons Learned at two Different Pilot Sites in the EU4ALL Project. JUCS - Journal of Universal Computer Science, 18(1). doi:10.3217/jucs-018-01-0062
14. Sánchez Gordón, S., & Luján Mora, S. (2015). Adaptive content presentation extension for open edX. Enhancing MOOCs accessibility for users with disabilities. ACHI 2015. 181-183.
15. World Health Organization. (2001). International Classification of Functioning, Disability and Health (ICF). Geneva: World Health Organization.
16. Brooke, J. (1996). SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), 4-7.
17. Van Selm, M., & Jankowski, N. W. (2006). Conducting Online Surveys. Quality and Quantity, 40(3), 435–456. doi:10.1007/s11135-005-8081-8
18. Vallerand, R. J. (1997). Toward A Hierarchical Model of Intrinsic and Extrinsic Motivation. Advances in Experimental Social Psychology Volume 29, 271–360. doi:10.1016/s0065-2601(08)60019-2
19. Lee, Y., Lee, J., & Hwang, Y. (2015). Relating motivation to information and communication technology acceptance: Self-determination theory perspective. Computers in Human Behavior, 51, 418–428. doi:10.1016/j.chb.2015.05.021
20. Roca, J. C., & Gagné, M. (2008). Understanding e-learning continuance intention in the workplace: A self-determination theory perspective. Computers in Human Behavior, 24(4), 1585–1604. doi:10.1016/j.chb.2007.06.001
21. Dupuy, L., Consel, C., & Sauzéon, H. (2016). Self-determination-based design to achieve acceptance of assisted living technologies for older adults. Computers in Human Behavior, 65, 508–521. doi:10.1016/j.chb.2016.07.042
22. Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An Empirical Evaluation of the System Usability Scale. International Journal of Human-Computer Interaction, 24(6), 574–594. doi:10.1080/10447310802205776
23. Kizilcec, R. F., Saltarelli, A. J., Reich, J., & Cohen, G. L. (2017). Closing global achievement gaps in MOOCs. Science, 355(6322), 251–252. doi:10.1126/science.aag2063
24. Zahed-Babelan, A., & Moenikia, M. (2010). The role of emotional intelligence in predicting students' academic achievement in distance education system. Procedia - Social and Behavioral Sciences, 2(2), 1158–1163. doi:10.1016/j.sbspro.2010.03.164
25. Iniesto, F., McAndrew, P., Minocha, S., & Coughlan, T. (2017). What are the Expectations of Disabled Learners when Participating in a MOOC? Proceedings of the Fourth (2017) ACM Conference on Learning @ Scale - L@S '17. doi:10.1145/3051457.3053991