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LONG PAPER

MoocCast: evaluating mobile-screencast for online courses

Bernardo Tabuenca[1] · **Marco Kalz**[2] · **Ansje Löhr**[3]

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Abstract The progressive adoption of smartphones and interconnected devices is inspiring students to redesign their physical spaces toward a seamless shift between daily life and learning activities. In the last years, Massive Open Online Courses (MOOCs) represent one of the key resources facilitating universal access to education as they enable students to learn across formal and informal contexts. However, there is little research exploring these alternative ways to present the content offered to learners in MOOCs for improved accessibility from personal contexts. This work presents the first study evaluating mobile-screencast technology as a means to facilitate learning processes in online courses. The contribution from this manuscript is threefold: First, preferred learning spaces for students enrolled to accomplish the activities in a MOOC are identified; second, mobile-screencast is evaluated as a solution for improved accessibility in online courses; third, an open tool for mobile-screencast and initial results from a formative evaluation are presented. This tool can be reused and adapted in further MOOC implementations. Finally, lessons learned are discussed and cues for future implementations are challenged.

Keywords Screencast · MOOC · Mobile learning · Learning environments

✉ Bernardo Tabuenca
bernardo.tabuenca@upm.es

Marco Kalz
marco.kalz@ou.nl

Ansje Löhr
ansje.lohr@ou.nl

[1] Escuela Técnica Superior de Ingeniería de Sistemas Informáticos, Universidad Politécnica de Madrid, Calle de Alan Turing, s/n, 28031 Madrid, Spain

[2] UNESCO Chair of Open Education, Faculty of Management, Science and Technology and Welten Institute, Open University of the Netherlands, Heerlen, The Netherlands

[3] Faculty of Management, Science and Technology, Open University of the Netherlands, Heerlen, The Netherlands

1 Introduction

The proliferation of interconnected devices is shaping the way we learn in daily spaces. Nowadays students redesign learning environments in recognition of the places in which they perform interactions with colleagues, as well as the artifacts and resources through which they achieve their learning goals [1]. Indeed, recent reports pinpoint to *Redesigning Learning Spaces* as one of the key trends accelerating technology adoption in Higher Education in the midterm (3–5 years) [2]. These sets of interconnected devices people use to access information have been lately termed *Device Mesh* [3]: "In the post-mobile world the focus shifts to the mobile user who is surrounded by a mesh of devices extending well beyond traditional mobile devices." A recent survey identifies preferred daily spaces for students to accomplish learning activities with their mobile devices [4]. The results show that learning activities are mainly performed when students are situated in a static and private context (i.e., at home sat on the sofa, desk, bed or commuting by train/bus). Therefore, it is key for the information society to provide technology that enhances learning processes in those frequently used daily living spaces.

Mobile devices are increasingly connected to back-end systems and it is expected that ubiquitous models will expand, and greater cooperative interaction between

devices will emerge [3]. Research performed in the last years is progressively reinforcing this vision: One example is the *LearnTracker,* a mobile tool that facilitates students to keep track of the learning activities performed in daily living spaces with the aim to foster reflection and to identify the places/moments of the day where/when they perform better ([5] built on NFC technology). In subsequent research, this mobile tool was extended with further artifacts as a means to provide feedback on the learning performance using a smart lamp ([6] built on Arduino) and proximity sensors ([7] built on Bluetooth Low Energy beacons). Another example is the *Presentation Trainer*, a tool designed to support the practice of nonverbal communication skills for public speaking. The tool tracks the user's voice and body to analyze her performance and selects the type of real-time feedback to be presented ([8] built on Kinect and HD display). These examples represent prominent technologies built to enhance learning beyond the walls of the classroom. This research focuses on two key trends in the field of technology-enhanced learning: screencast technology and Massive Open Online Courses (MOOCs).

Screencast technology has become more popular since digital media players reached the market[1] in 2013. With screencast technology a user can send content from a phone (such as a YouTube or Netflix video you might be watching) to a TV. Moreover, screencast devices are simple to configure, portable (as they can be easily moved from one TV to another), and they are not expensive. Its key role as facilitator to access learning content is probably the most relevant advantage for students. Hence, whenever a student is interested to watch a short video about Geology and Earth science, this technology allows to "beam" content he was looking at on his smartphone or tablet in high definition to a display. These devices broadcast audio and video content on a high-definition display by direct streaming via Wi-Fi from the Internet. Screencast technologies enable such dynamic binding over ad hoc one-hop networks or Wi-Fi access points. Hence, the binding between computing devices and displays is no longer one-to-one but more dynamic and adaptive [9]. This work aims at exploring and evaluating the usage of screencast technology to promote learning processes in daily physical spaces. Via this approach, learners are able to access learning content beyond traditional contexts with a direct effect on accessibility. The guiding theoretical foundation for the work presented in the paper is the seamless learning framework [10].

Seamless learning places the learner in the center of a context in which access to cognitive tools is given, and space, time and artifacts are influencing the behavior of learners [11]. The framework also takes into account the difference between the public space and the private space of the learner. The theory proposes 10 different seams that are often challenging learners from a continuous and rich learning experience [10]. Our work relates to the following challenges for seamless learning: (1) encompassing formal and informal learning; (2) encompassing physical and digital worlds; (3) combined use of multiple devices.

The MOOC phenomenon has become widely acknowledged as crucial for freely accessible high-quality courses for a massive number of learners from anywhere all over the world over the last decade [12]. They facilitate access to learning resources on a global scale and help to overcome barriers for lifelong learning [13]. Although there has been critique about shortcoming of the current approach to MOOC design [14], video lectures represent one of the key formats to deliver educational content in MOOCs. Initially, access to MOOCs was solely possible through desktop computers. While the educational technology community was giving, at that time, more attention to mobile and contextual learning approaches, MOOCs were in that respect a step back to the desktop paradigm. Later, MOOC platforms also facilitated access to course content via mobile devices. Systematic reviews analyzing the use of video lectures in MOOCs tackle issues regarding the duration of the videos, positioning of the speaker, slides usage, recording style, production, or technical implementation of the videos [15, 16]. However, studies do not deal with students' preferences with regard to their learning spaces or the way students use their devices to watch the videos included in MOOCs. To the best of our knowledge, this is the first study evaluating the use of screencast technology in online settings.

1.1 Related work

Mobile access to Open Educational Resources (OER) has been identified as a research challenge. An earlier analysis of mobile access to OER portals has shown that a high percentage of portals does not fully embrace the potential of mobile access to learning resources [17]. For MOOCs, a similar challenge can be identified. Authors in [18] have analyzed the potential convergence between MOOCs and mobile learning, highlighting a similar nature and stressing the potential for socially embedded lifelong learning. Current discussion of the connection between mobile learning and MOOCs often stresses the access aspect of content. Our focus lies on the reuse of learning content from MOOCs in the personal spaces of learners with screencast technology.

Podcasting and screencasting have been evaluated in classroom settings with positive learning effects.

[1] Release of the main screencast technologies to the market: Google Chromecast/July 2013; Roku/March 2013; Apple TV January 2013.

Podcasting is associated with numerous positive learning outcomes affecting increased satisfaction, motivation, engagement, attitudes and anxiety reduction [19–21]. Previous research demonstrates that screencast tutorials are an effective and efficient tool for enhancing student learning compared to traditional instructional techniques [22].

This work contrasts previous research in three main aspects:

(1) Instead of the potential of mobile access to learning resources, our research is focusing on the recontextualization of MOOC video content in the private spaces of learners.
(2) Pre-downloaded versus real time streaming. In previous research, multimedia content was pre-downloaded to the computer and later on broadcasted to students. Digital media players have evolved as the bandwidth has progressively grown in the last years. Here we use a device mesh comprising (1) a mobile device, (2) a digital media player, (3) an HDMI display, (4) Wi-Fi Internet connection and (5) video content from a MOOC to provide cues on how to redesign learning spaces. The tool presented and evaluated in this study casts videos streamed directly from the Internet.
(3) Face-to-face versus online. In previous research, experiments were performed in face-to-face classrooms where students were more constrained to redesign their learning spaces. This manuscript presents a study accomplished on a virtual environment in which students learn ubiquitously anywhere and anytime.

1.2 Research focus

This work is guided by the following research questions:

Research question 1 (RQ1) What insights can be highlighted with regard to users' habits to learn in MOOCs? We will explore learning patterns, preferred learning environments and preferred devices to follow the course.
Research question 2 (RQ2) What observations can be pinpointed with regard to the use of videos and screencast technology in MOOCs? We will explore users' preferences to watch videos, quantify the popularity of screencast technology and evaluate its acceptance.

This manuscript is organized as follows: Sect. 2 presents *MoocCast* as novel tool to cast the videos included in a MOOC from the mobile device to an HDMI display. Section 3 presents the results of a study exploring patterns of students watching videos in MOOCs and their acceptance of the screencast tool. Section 4 discusses the relevance of the results and identifies potential uses of screencast toward promoting digital learning processes.

2 MoocCast: an open mobile tool to cast video content

MoocCast is a mobile tool developed with the aim to provide screencast features to MOOCs. The first pilot of the tool was designed as a novel interaction approach featuring navigation within the app menus taping tags stuck on physical objects ([23] March 2014). The second version of the tool was simplified and adapted for a MOOC on Marine Litter (October 2015). This tool was evaluated and the results are presented. As a consequence of the lessons learned during the MOOC, the tool was improved and openly released to any forthcoming MOOC implementation (September 2016).

MoocCast has been designed on the notion that any instructional designer can create a playlist of videos comprising the contents of a specific course and share it online so that the participants enrolled in the course can upload the playlist and watch the videos. This setup comprises:

2.1 Digital media player

Recently, Wi-Fi enabled digital media players have arrived to the market. Examples of these are Google Chromecast,[2] Roku[3] and Apple TV.[4] These devices stream multimedia content based on the commands (Play, Pause and Stop) triggered from another networked device (i.e., laptop, tablet, mobile). The basic operation is that using your personal device as a remote and selecting the desired multimedia, the content is automatically broadcasted in the HDMI display where the digital media player is plugged. The combination of devices presented in this manuscript has been developed for Google Chromecast.[5]

2.2 HDMI display

HDMI displays facilitate the visualization of videos independently of the dimension for which they were designed. When streaming video from the digital media player, the audio volume is controlled from the remote of the HDMI

[2] Google Chromecast. http://www.google.com/intl/en/chrome/devices/chromecast/.
[3] Roku streaming stick. http://www.roku.com/products/streaming-stick.
[4] APPLE TV streamcater. http://www.apple.com/appletv/.
[5] Google Cast SDK. https://developers.google.com/cast/docs/reference/.

display and not from the client device (mobile device, tablet or laptop). This feature makes the interaction much more natural and integrated within daily life environment.

2.3 MoocCast

MoocCast has been developed and released[6] for the Android operating system in September 2016. When the app starts, it loads the JSON file (Fig. 1b) containing the videos of the MOOC. The basic functionality of the tool is distributed in three screens (see Fig. 2).

1. The playlist screen is the starting point of the tool (Fig. 2a). This screen comprises the bundle of videos comprised in the selected course.
2. The cast screen is presented when one of the videos from the list is selected (Fig. 2b). This interface is the remote control of the app in which the user can Play, Pause and Stop the video. Here the user can watch the video directly in his/her own mobile device or alternatively cast the videos to the HDMI display via Chromecast.
3. The configuration screen is the interface where the user specifies the URL of the structured file describing the playlist of the course (Fig. 2c).

Playlists are structured in JSON files in the following fields (Fig. 1b):

- Name: Name that identifies the course (e.g., "MOOC on Marine Litter").
- Title: Short description of the video (e.g., "1. Introduction to the course").
- Subtitle: Extended description of the video (e.g., "This video introduces you to the world of…").
- Source: URL where the video is stored (e.g., "https://player.vimeo.com/14183.sd.mp4").
- Thumb: Images presented in the playlist screen to identify the video. The image should be size 480 × 720 pixels and jpeg format (e.g., "http://…/Library/Images/…/111-480x270.jpg").
- Image-480 × 270: Image displayed on the mobile while the video is being casted. The image should be size 480 × 720 pixels and jpeg format.
- Image-780 × 1200: Image displayed on the HDMI while the video is being loaded. The image should be size 780 × 1200 pixels and jpeg format.
- Studio: University/Institution or author and year when the video was created (e.g., "OUNL 2016").

The path of the images can be relative to the location of the json file (e.g., "images/111-480x270.jpg") or an URL in Internet (e.g., "http://…/Library/Images/…/111-480x270.jpg").

MoocCast is an open project with regard to the following aspects: (1) MoocCast is available as open source.[7] The source code from this tool has been released under Apache License, Version 2.0, to enable further adaptations and developments; (2) MoocCast is distributed free of cost in Google Play; (3) MoocCast is reusable by any MOOC.

3 Method

The amount of plastics in the environment is gradually increasing [24], and there is a growing concern about the risks and possible adverse effects to the marine environment. In 2015, therefore, the United Nations Environment Programme (UNEP), in cooperation with the Open University of the Netherlands, developed the first Massive Open Online Course (MOOC) on Marine Litter. The MOOC was created to stimulate leadership and to offer opportunities for actionable and change-oriented learning related to Marine Litter within the framework of the Global Partnership on Marine Litter (GPA[8]). In the MOOC design participants were activated and motivated to combat Marine Litter in networks with relevant stakeholders with a main focus on prevention and reduction of Marine Litter. This study was accomplished between October 2015 and January 2016.

3.1 Participants

As a result of the worldwide promotion performed by United Nations Environmental Programme (UNEP) and the GPA, a total of 6452 students enrolled in the Marine Litter MOOC. Data were collected using online forms. Participants in the study voluntarily signed the consent form and completed the pre-/post-questionnaires. The MOOC started in October 2015 and was available in two optional tracks: a leadership track (2-week duration) and an expert track (6-week duration). At the end of the course, participants were encouraged to perform a project-based activity, in which participants had to develop an action plan and address a local/regional or specific Marine Litter issue, extending the course until February 2016. A high percentage of participants were female (70%), and students obtained a

[6] MoocCast in Google Play. https://play.google.com/store/apps/details?id=org.ounl.mooccaster.

[7] MoocCast source repository: https://github.com/btabuenca/Android/tree/master/workspaceMediaPlayer/MoocCast.

[8] Global Programme of Action for the Protection of the Marine Environment from Land-based Activities a voluntary open-ended partnership for international agencies, governments, businesses, academia, local authorities, nongovernmental organizations and individuals.

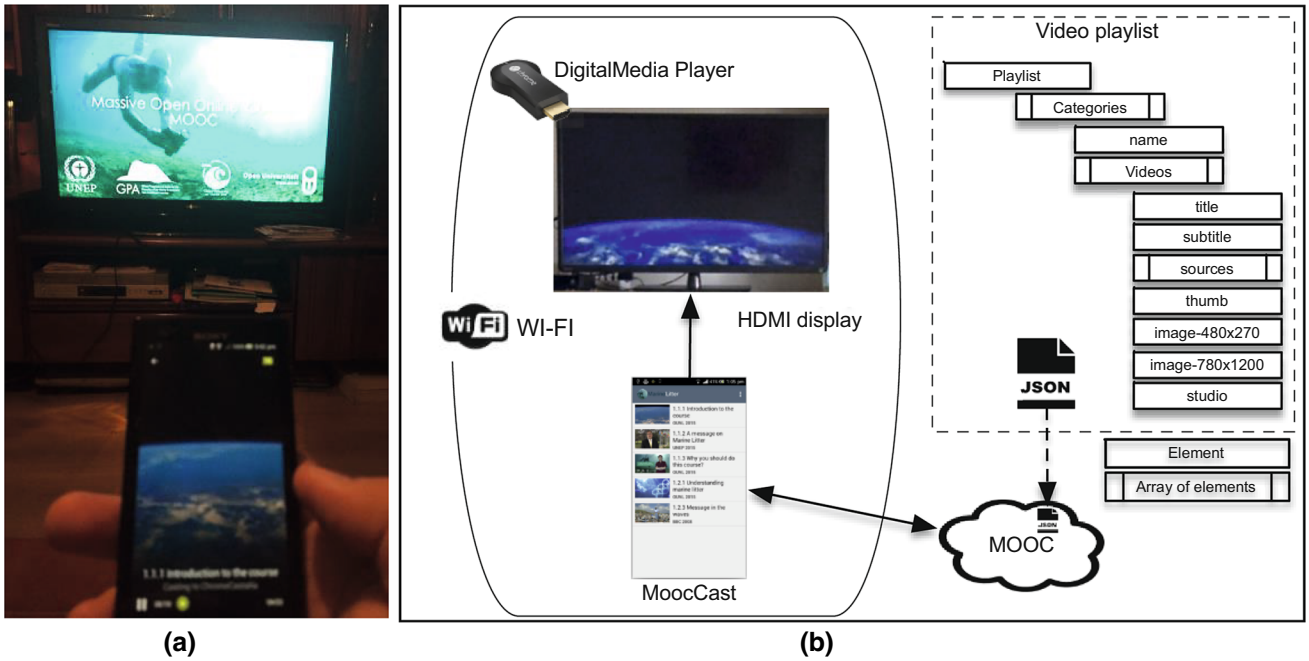

Fig. 1 MoocCast: a device mesh. **a,** screencast via mobile. **b**, tecnologies and configuration

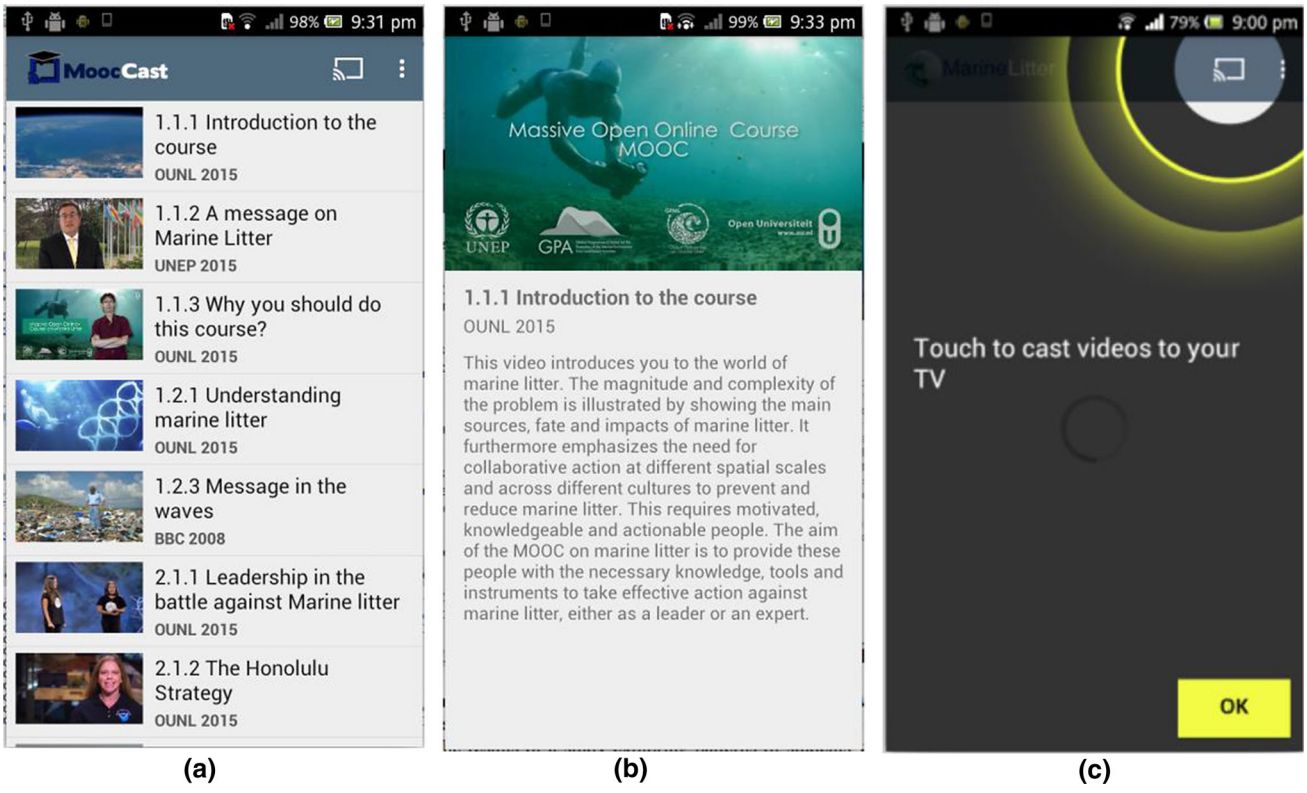

Fig. 2 MoocCast navigation. **a** Playlist screen, **b** cast screen, **c** configuration screen

Table 1 Demographics

Surveys completed	Pre-questionnaire $n = 689$	Post-questionnaire $n = 123$
Gender		
Female	70.25%	66.6%
Male	29.75%	33.4%
Age		
Less than 20	2.17%	1%
Between 20 and 39	62.26%	52%
Between 40 and 59	28.01%	39%
More than 59	7.54%	24%
Country of residence		
Total	USA 17%	USA 9%
	UK 6%	The Netherlands 7%
	The Netherlands 5%	Germany 6%
	Spain 5%	Spain 5%
	Australia 3%	UK 5%
	Italy 3%	Canada 4%
	Philippines 3%	Belgium 4%
	Other countries 58%	Other countries 60%
	94 different countries	46 different countries

certificate of participation after the completion of any of the tracks (see Table 1).

3.2 Materials

This evaluation has involved the following tools and materials:

- MOOC Online Portal.[9] A web-based portal in which students could enroll, follow the activities of the course and interact with teachers and colleagues. The course included text materials, videos, forums, assignments and collaborative maps to spot Marine Litter within their region.
- Marine Litter MOOC APP for Android.[10] This tool gathered a bundle of 53 videos included in the course. The videos were stored in Vimeo as repository. The images referenced in the JSON file were stored in the public Dropbox folder.

3.3 Design of the experiment and measure instruments

The design of this experiment consisted of two measures: (1) A pre-questionnaire gathered demographics (see Table 1), their expected learning goals and the type of devices they would use to follow the course; (2) a post-questionnaire gathered their accomplished learning goals, accessibility of the course, learning patterns used and overall satisfaction of the screencast tool.

3.4 Procedure

The researchers sent an email invitation to encourage enrolled students to participate in the study three weeks before the start of the experiment. The invitation was also broadcasted in the forum of the course. The survey was closed when the course started. At the end of the course, all participants enrolled were invited again to complete the post-questionnaire using the same channels. Students could complete it in the subsequent four weeks.

3.5 Data analysis

The data were analyzed using open software tools. Hence, questionnaire data were imported from the survey platform into CSV format and then inserted into a database. SQL queries were formulated in order to construct a suitable dataset that was finally analyzed with R Studio (v0.98.1102).

3.6 Results

The following questions were formulated to explore "What insights can be highlighted with regard to users' habits to learn in MOOCs?" (RQ1) (Table 2).

The following questions were formulated to explore "What observations can be pinpointed with regard to the use of videos and screencast technology in MOOCs?" (RQ2) (Table 3).

4 Discussion and conclusions

4.1 Interpretation of the results

We explored what insights can be highlighted with regard to users' preferences to learn in MOOCs. When participants were asked which device they had used the most to follow the course, almost 80% of the participants voted for the laptop whereas 3% reported they had used their tablet or smartphone. These results may challenge current assumptions envisioning that mobile devices might soon take the place of laptops or desktop computers when learning online. On the other hand, since the learning experience on mobile phones and tablet computers is still substantially different compared to desktops, this might be a typical hen-and-egg problem. According to a 2013 report

[9] Marine Litter MOOC portal: https://www.marinelittermooc.org/.

[10] Marine Litter MOOC APP. Released in October 2015. More than 400 downloads in Google Play. https://play.google.com/store/apps/details?id=org.ounl.btb.mooccaster&hl=en.

Table 2 Research question 1

Post-questionnaire	$n = 123$	
What was your preferred learning context to follow the course?	Yes	No
At home at my desk	72%	27%
At home on the couch	24%	76%
At work	23%	76%
Lying on the bed	10%	89%
At an educational institution	9%	90%
During waiting times	8%	91%
In transition phases (traveling, commuting…)	5%	94%
At a library	4%	95%
Which device did you use most to follow the course?		
Laptop	79%	
Desktop computer	18%	
Tablet or smartphone	3%	
Select the patterns that better describe your behavior completing the units of the course		
Follow the predefined flow of the course	64%	
First watch all the videos	16%	
First read the text content	13%	
Skip the assignments	1%	
Other	4%	

[25], 43% of the learners who attended the survey ($n = 2000$) reported that they consider being able to access learning on their mobile devices "very useful." Hence, mobile devices can play a relevant role facilitating access to resources and/or connecting devices in daily learning environments. However, mobile screen is smaller and MOOCs usually require reading and writing long paragraphs. Although mobile phone screens have become bigger in recent years, they are still a lot smaller than the average desktop and laptop computer.

Recent reports envision that the practice of people bringing their own laptops, tablets, smartphones or other portable devices with them to learning or work environment (Bring Your Own Device) will have a short time of adoption in Higher Education [26]. When participants were asked which was their preferred learning environment to follow the course, students reported they had followed the course from home while sat on the desk (72%), sat on the couch (24%), at work (23%) or laid on bed (10%). These results confirm recent research concluding that learning activities using portable devices are mainly performed when students are situated in a static and private context [4]. Indeed, only 5% of the participants reported to progress in the MOOC in transition phases, e.g., traveling or commuting.

MOOCs comprise a set of learning units clustering contents in text and video format. We aimed at exploring whether students might vary their behavior following the course depending on the format of the contents. The results show that 36% of the participants do not follow the predefined order of the course (64%). Sixteen percentage preferred to first watch all the videos, whereas 13% preferred to first read all contents in text format. These results rekindle the need to provide technology that facilitates students to watch a sequence of videos without navigating across learning units. In this sense, tools like MoocCast might play an important role as facilitator.

We explored what observations can be pinpointed with regard to the use of videos and screencast technology in MOOCs. In first approach we asked participants whether they owned a smartphone to install MoocCast. Eighty-three percentage of the participants answered positively to this question. The source for the high percentage of non-smartphone countries is the high number of participants from non-developed countries.

Contrary to our expectations, a remarkable percentage of participants owned a digital media player to cast videos from their mobile device (25%). The most popular were Apple TV (29%), Google Chromecast (24%) and Roku (7%). Other streaming players (40%) are Amazon Fire TV, Nvidia Shield or Nexus Player. The popularity of streaming players depicted by these results shows the potential of this technology for further developments.

The duration of the videos in a MOOC is a key variable toward integrating learning and daily activities. Whenever videos have a suitable duration, these short learning episodes might be embedded into waiting times (e.g., commercials on TV or waiting for the bus) or time gaps happening throughout the day. In this MOOC, the majority of the participants (85%) preferred videos shorter than

Table 3 Research question 2

Pre-questionnaire	$n = 689$
Do you have a smartphone?	
Yes	83%
No	12%
NA	5%
Do you have any digital media player?	
Yes	25%
No	47%
NA	16%
I don't know	10%
If yes, which digital media player do you have?	
Other	40%
Apple TV	29%
Chromecast	24%
Roku	7%
Post-questionnaire	$n = 123$
What is your preferred duration for the videos in a MOOC?	
4–6 min	30%
7–9 min	25%
10–12 min	19%
13–15 min	11%
1–3 min	4%
16–18 min	3%
19–21 min	3%
More than 24 min	2%
Did you use the Marine Litter MOOC APP to watch the videos during the course?	
No	91% ($n = 122$)
Yes	9% ($n = 11$)
If yes, please rate how much do you agree?	9% ($n = 11$)
Likert scale [1..7]: 7—completely agree; 1—completely disagree	
The mobile video app has helped me to keep engaged in the course	6.00
Overall. The mobile app has enriched my learning experience	5.80
Did you use Chromecast to stream the videos of the course?	
No	91% ($n = 122$)
Yes	9% ($n = 11$)
If yes, please rate how much do you agree?	9% ($n = 11$)
Likert scale [1..7]: 7—completely agree; 1—completely disagree	
The casting feature has added an important value to the learning experience	5.57

20 min. More specifically, 55% of the participants preferred videos between 4 and 9 min.

In the last question, we asked screencast users (9%) about their overall satisfaction of the tool in a 7-Likert scale (7—completely agree; 1—completely disagree). The results were quite positive obtaining values that ranged between 5.57 and 6.00. Participants that used the tool had a good level of satisfaction. These results should be contrasted in further studies with a higher number of (cast-)participants to explore whether this positive satisfaction has an impact engaging the students in the MOOC.

4.2 Significance of the study and challenges

This research contributes to new knowledge for universal access presenting a *device mesh* comprising a set of novel technologies to cast video content from a MOOC to an HDMI display using a mobile device as a remote. The tool has been evaluated in the context of the first MOOC on Marine Litter, and the results have been discussed. An evolution of the tool (MoocCast) has been presented with the aim to open its features to any forthcoming MOOC or online course implementation as means to ensure universal access to this technology. To the best of our knowledge, these issues were not addressed by existing research.

As a result of this study, we envision that mobile-screencast technology might bring the following challenges to be taken into account in further research:

- Support for disabled students. Screencast might help students with visual impairment. Hence, videos that are normally played on a laptop computer or a mobile device might be casted to bigger HDMI display to alleviate this loss. Likewise, screencast might help students with hearing impairment to properly listen video and audio content because HDMI displays are equipped with more powerful speakers than computers.
- Collaborative classrooms. Screencast players accept requests from any (mobile) device connected to the same Wi-Fi. Collaborative sessions might be featured in which any student could take control of the display installed in the classroom from his mobile device, and cast videos to share them with the rest of the students. Hence, screencast technology might bring new challenges for collaborative classrooms. Likewise, the teacher might use his mobile device to prepare a playlist about the lecture and cast the content during the session.
- Video support for public spaces. Common areas, university halls, museums or waiting rooms are normally equipped with HDMI displays. Playlists might be created and shared, e.g., newcomers guide for university students, or a video guide describing the pictures in a museum.

4.3 Limitations and lessons learned

This study involved a low number of users. Mobile-screencast could only be evaluated by students that owned an Android mobile device, and Google Chromecast as digital player. MoocCast was developed for Android

because it is by far the operating system with more smartphone sales in the last year.[11] MoocCast was developed for Google Chromecast because of its popularity. Additionally and contrary to other vendors, Google released their API, libraries and a development kit[12] to enable new developments. This limitation could be overcome developing new MoocCast apps for iOS mobile as Chromecast features open libraries for this operating system. Alternatively, users can beam whatever they are looking at in the Chrome browser of the laptop to their TV. This feature requires installing Google Cast extension for the Chrome browser. We consider that screencast users might grow in the coming years at the same pace that on-demand TV is growing in developed countries.

The videos used in the experiment were shared using Vimeo,[13] YouTube and the OUNL-Videotheek as video repositories. Some students from India and Indonesia claimed that they could not watch the videos in Vimeo. When designing a playlist for a MOOC, instructional designers should take into account that some countries block some of these repositories whereas other countries censor specific videos within repositories (e.g., GEMA in Germany). Hence, alternative options in private repositories should be explored when the videos are casted in those countries.

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