PORTABILITY AND USABILITY OF OPEN EDUCATIONAL RESOURCES ON MOBILE DEVICES: A STUDY IN THE CONTEXT OF BRAZILIAN EDUCATIONAL PORTALS AND ANDROID-BASED DEVICES

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ABSTRACT

Open Educational Resources (OER) are freely accessible, openly licensed hypertext, audio, video, simulations, games and animations that are useful for teaching and learning purposes. In order to facilitate the location of such resources, educational content portals are being created, crowding contents that were produced by different teams with different technologies usually designed to be accessed by conventional computers equipped with keyboard, mouse and a medium-sized screen. Since these resources are available in Internet and with the popularity of smartphones and tablets it is necessary to study the portability and the usability of these resources when accessed by these devices, which user interact with fingers. Due the changing of the input modalities and other device´s characteristics some usability problems can occur and can impair the use of these resources in mobile devices. This exploratory study intended to raise and analyze possible difficulties of interaction between users and educational software designed for desktop accessed through mobile devices like tablet and smartphone. We discuss data about three educational resources accessed in two android-based mobile devices, a smartphone and a tablet, and identified several problems that resources´ developers need to take account to produce resource for be accessed in desktops and mobile devices and the problem of download and running OER on mobile devices.

KEYWORDS

Mobile devices; Open Educational Resource; Portability; Usability.

1. INTRODUCTION

Open Educational Resources (OER) are freely accessible, openly licensed hypertext, audio, video, simulations, games and animations that are useful for teaching and learning purposes. In order to facilitate the searching for OER, digital educational content portals are created to be a storage location for resources that were produced by different teams with different technologies usually designed to be accessed by conventional computers. The Brazil´s Ministry of Education (MEC) created some portals such *RIVED*, *Portal do Professor* (Teacher´s Portal) and *Portal International de Objetos Educationais* (International Database of Educational Objects) portals and it is encouraging the development of resources through partnerships with Brazilian´s educational institutions. One of the requirements is portability among many desktop´s operating systems; so, developers used formats that are not platform-dependent.

Mobile devices, such as smartphones and tablets, are becoming increasingly popular; most of them have touch screen displays, are easy to carry, have autonomy for hours, Internet access and enough computing power to process Web pages, audio and video files. So, it is possible access OER, initially developed to be used with keyboard, mouse and a medium size display, by touch screen devices. And this is expected to

happen; most users say they would like to see more content for access by mobile, and given the growing use of smartphones and access to applications for these devices, it is expected that students use these resources in their learning activities, increasing the number of people who benefit from m-learning (mobile learning), the use of mobile devices to support learning. Thus, it is necessary to study the portability and usability of OER when they are accessed by mobile devices.

With this motivation, we studied the portability and usability of six OER available at Brazilian educational portals accessing them by two android-based devices, a smartphone and a tablet. Here we present the three most significant cases. Some questions that guide this work: Are the applications and content available on the portals of educational resources portable to mobile devices? What is the impact of access this content originally developed for desktop computers in smartphones?

As results we found restrictions of use of a set of OER available on the portals and some problems that were used to generate some guidelines for development teams. In Section 2 we presented some related work. Section 3 and 4 we presented the used materials and method and analyze of the collected data. In Section 5 we present the conclusion.

2. RELATED WORK

Nielsen (1993) defines the general acceptability of a system, composed by social acceptability and practical acceptability. One of the concepts that compose the practice acceptance is the "usefulness", which refers to the system can be used to achieve a particular objective. This concept consists of the usefulness and usability. Usability is a combination of five elements: ease of learning, efficiency, ease of remember, probability of the user making few errors and user satisfaction.

Norman and Nielsen (2010) commented about the disappearance of some fundamental design principles in touchscreen devices like iPad. These principles cited by Norman and Nielsen are technology-independent: i) visibility (a form of interaction adopted, such as a gesture on an object must be present in all parts of the application when the object is on the screen); ii) feedback (system offers an answer to the user action and the response returned by the system must be the answer expected by users); iii) consistency (in relation to interaction objects of the application, the platform and between platforms); iv) non-destructive operations (so it is important to have the functionality “undo”); v) discoverability (operation can be discovered through the exploration of menus); vi) scalability (the features should work in small, medium or large screens); vii) trust (the features must run and the events cannot occur randomly).

These problems and others related with portability and usability can be identified through an analysis of user interaction, using available (and validated by the literature) methods for evaluate the user interfaces. Methods to evaluate user interfaces can be categorized by inspection methods and empirical tests. Inspection methods involve usability experts whose advantages are low cost, rapid implementation and learning and efficiency to find errors and usability problems. The inspection methods are usually applied before other methods to complement the evaluation of the interface, as user tests. Empirical tests involve the participation of users and can be performed in or out the laboratory; usability problems can be identified by analyzing the user interaction or by a survey with questions about the use of the system.

In our previous work we studied the interactions of users performing tasks that required the use of some tools in the TelEduc Environment, whose design was developed for use in desktop computers with mouse, keyboard and a high resolution medium-sized screen, on three devices - desktop, a touch screen smartphone, and a touch screen tablet. We identified interaction problems and classified them into three categories: i) caused by modality changing; ii) caused by platform changing; and iii) those that are independent of platform or modality changing, but that could be identified due the use of more than one device. Here, in this paper, we focus on OER instead of an e-learning environment, but the approach is similar.

Similar with e-Learning environments, most of OER were developed to be accessed by desktop computers equipped with keyboard, mouse and high resolution medium-sized screen. When change the platform or the modality (from mouse plus keyboard to touch) some interaction problems happen.

The International Database of Educational Objects portal is a repository created in 2008 by the Brazil´s Ministry of Education (MEC), in partnership with the Brazil´s Ministry of Science and Technology, the Latin American Network of Educational Portals (RELPE) and the Organization of Ibero-American States (OEI). This portal, integrated with Teacher’s Portal, offers free digital objects such as videos, audios, images,

educational games and software, animations and simulations from primary school to higher education levels. The portal offer statistics about the objects and describe that, in 2013, there are 5,926 simulations, 4,304 video files, 3,613 images, 3,067 audio files, 1,759 experiments, 794 educational software, 240 hypertext files and 21 maps.

In the International Database of Educational Objects portal there are 10,221 objects for college level, 9,200 for high level, 5,048 for basic education, 851 for childhood education and 483 for professional education. There are 4,562 objects about Mathematics, 3,223 about Physics, 2,089 about Chemistry, 1,576 about Biology, 1,438 about Foreign Language (e.g., English and Spanish), 1,420 about Portuguese and others courses.

One important requirement of OER is be usable in many contexts, and so different platforms. Most of resources developed with Brazilian´s Ministry of Education founding must be developed to be available at Internet and run in Windows and Linux; so, portability between operating systems is required. To meet this requirement, developers have used technologies such HTML, JavaScript, Java, MPEG, MP3, AVI, JPG, GIF, PDF and Flash. Most of resources cataloged as Video are available in MPEG format. The resources cataloged as Audio are available in MP3 format. Images and Maps resources are in JPG format. For Educational Software, Animation/Simulation some are in Flash format, but there are resources developed in Java or in EXE format.

We consider portability problems as problems that are discovered during interaction with the mobile device and do not occur in the interaction performed in the desktop. We consider problems related with the response time (performance) as portability problem too.

3. MATERIALS AND METHOD

The materials used were: OER available at Brazilian portals; a Smartphone Motolora Milestone 1 with Android version 4.1.1; and a tablet Positivo. The tablet used in the session tests is a Brazilian Positivo Ypy, 1.0 GHz ARM Cortex A9 processor with 1 GB RAM and a 10in multi-touch screen 800 x480 pixels of resolution with Android operating system version 4.1.1. The smartphone used in the session is a Motorola Milestone which has a 600 MHz Cortex-A8 processor with 256 MB RAM and a 3.7in multi-touch display 854 x 480 pixels of resolution and Android version 4.0.3 as operation system.

The chosen OER need to run on mobile devices (be portable from desktop to mobile devices) for identify interaction problems and related them with usability. Since our work focused on interactivity, we searched for OER where the number of interaction between user and resource is higher and not limited in reading and forward or backward the screen. So, resources catalogued as images, maps, videos and audios are not analyzed; even though the content in these categories are portable for mobile devices, as described on Section 2. So we focused our efforts on OER catalogued as Animation/Simulation and Educational Software. In this case, the portability is related with the format; EXE files have low portability because just work on Windows operating system family. Java programs have a better portability, working on Windows and Linux operating systems, but not all mobile devices platforms support Java, some of them support Java ME, a special edition of Java for mobile devices. But Android-based mobile does not support directly Java Me applications, need some conversion. Some OER were developed using Flash Technology, running on Windows and Linux operating system after the installation of a free plugin to run Flash files. Flash files can run in Android-based devices because the Macromedia released a plugin for Android; one of our motivation to use Android-based devices. Since there is not Flash plugin for iOS operating systems, it is not possible to run Flash applications on iPad or iPhone.

4. DATA ANALYSIS

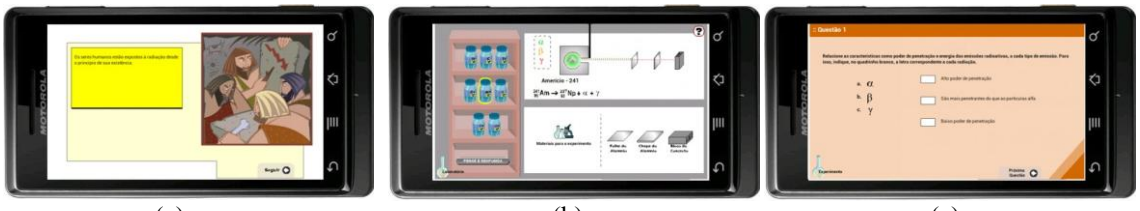
The first resource evaluated was the "*Propriedades das emissões radioativas: poder de penetração*" (Properties of radioactive emissions: power of penetration), available at the International Database of Educational Objects and the RIVED Portal and classified as animation/simulation. This simulation is for college students and the educational goals are: i) teaching the power of penetration of radioactive emissions alpha, beta and gamma; ii) recognizing that the power of a particle´s penetration is related to its energy; iii)

establishing a relationship between the power of penetration and possible damage to living beings; and iv) forms of protection. Fig. 1 shows some screenshots of the resource executed in a desktop computer on Firefox browser. The simulation begin within an explanation about the radiation and how it is dangerous for living beings (Fig. 1a); after the end of the explanation the equipment is presented, which is composed of electrified plates, a box of lead and isotopes. The user can know the components´ name through a message balloon that is displayed when the mouse pointer is over the component. Clicking in the box of lead, the experiment screen is displayed (Fig. 1b), where the user can chose an isotope (in the left), putting it inside the box of lead (top), select materials for experiments such as paper sheet, aluminum sheet, lead sheet, aluminum plate, wood plate, steel plate, lead plate, concrete block and human hand (in the screen bottom, selecting the option materials for the experiment). After choosing the isotope and up to three materials experiment, the user can open the lead box touching the black plate for radiation get out. According the isotope alpha, beta or gamma rays will be issued. In the bottom of the left-side there is a button that displays some questions to be answering (Fig. 1c). An usability evaluation running the OER in a desktop was done, and the following problems are identified: i) knowing which objects are clickable in the experiment screen (the only way is put the mouse pointer over and see if the pointer change); ii) when the user change the isotope, all materials are removed and need to be selected again; iii) it is not possible to change the order of the materials without remove them and adding one by one in the desire order.

In the Fig. 2 are showed the same screens but running the OER in the Android-based smartphone. It is noticed that the position of the interface elements continues with the same appearance and location, which, in terms of usability, it is positive because maintain the consistence. However, after the test case, it was possible to identify some usability problems that occur when run this OER on mobile devices, such as: i) the font size could be higher on mobile devices; ii) difficulty in opening the black plate that closes the lead box using the finger (it was easily accomplished through the mouse pointer on the desktop); iii) some plataform characteristics are not respect; e.g., to change pages in a mobile reader application the user just touch the screen and move the finger for left or for right. In the explanation screens it is not possible to use this gesture to go to the next text.

(a) (b) (c)

Figure 1. Educational simulation resource “Properties of radioactive emissions: power of penetration” executed in a desktop computer on a Firefox browser: (a) home screen with explanation; (b) laboratory screen to perform experiments; (c) screen with question to answer.



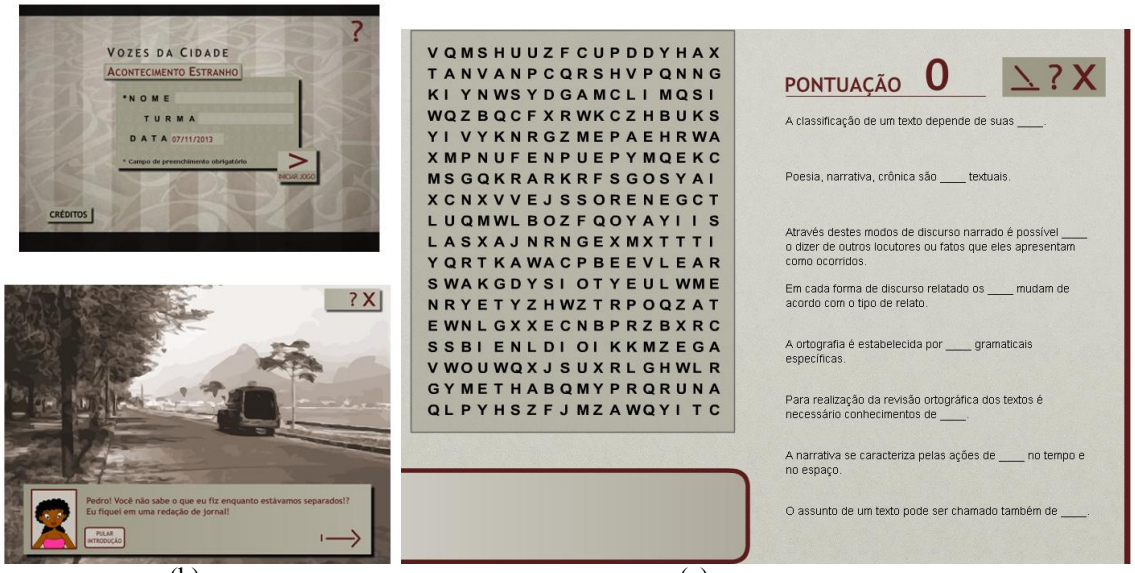
(a) (b) (c)

Figure 2. Educational simulation resource “Properties of radioactive emissions: power of penetration” executed in an Android-based smartphone: (a) home screen with explanation; (b) laboratory screen to perform experiments; (c) screen with question to answer.

Another identified problem is related with the devices; since the smartphone (and tablets too) does not recognize the finger proximity (they only recognize the touch), the user could have problem in interact with elements which have features triggered by mouse pointer over, such as interact to know the name of the laboratory components. This problem was attenuated because few objects in this resource have a feature triggered by mouse pointer over and another feature triggered by clicking; in components where there are different features triggered by mouse pointer over and by clicking, the ballon with the component name is display, but the screen is changed so fast that it is not possible to read the component name.

In the tablet, a device with a medium-sized screen, the font size is adequade for reading, the response time was considered appropriate, but i) the mouse pointer over problem occur; ii) there is not possible to navigate through the explanations using gestures; iii) the resource does not consider the rotation screen, working only on landscape format. All resources analyzed and developed in Flash, described below, have this problem in common.

The second resource evaluated was "*Programa Vozes na Cidade – Acontecimento Estranho*" (Voices of the City Show – Strange Event), a word search game catalogued as simulation/animation about grammar, showed in Fig. 3. The game goals are: i) observe the different ways of moving an idea indirectly; ii) analyze various texts from its textual organization; iii) reflect upon the orthographic norms; iv) analyze the different stages of text production, with emphasis on the review; v) analyze the different ways that speech can be: direct speech, indirect and free indirect; vi) analyze the textual significance considering its inhomogeneity; vii) analyze of the various stages of production of a newspaper.



(b) (c)

Figure 3. Educational resource "Voices of the City Show – Strange Event" executed in a desktop computer: (a) home screen; (b) introduction screen; (c) the word search screen.

(a) (b)

Figure 4. Educational resource "Voices of the City Show – Strange Event" executed in an Android-based smartphone: (a) home screen with the virtual keyboard over the form; (b) the word search screen.

The home screen (Fig. 3a) shows the name of the application with three fields (to fill with the name, class and date, but only the name is required). At the top of the right side we have a question mark to access the tutorial; this element can be accessed on all screens of the game. After fill the form and press the button to start the game ("*Iniciar Jogo"* button), an introductory history is presented (Fig. 3b); the user can read the text, a conversation between two personages, or skip this presentation. The next screen (Fig. 3c) presents the place where the user needs to find the words (left side) that are missing in the phrases (right side). When the user identifies a word and select it clicking in the first letter and moving the mouse pointer to the last letter (or vice versa), the word will be showed in the box below the search word place. So the user can drag and drop the identified word putting in a blank space. The user earns points when she hit the space for the word, and loses if she put in the wrong space. At the end, or clicking in the pencil icon at the top of the screen, a report is displayed.

In the tablet few interaction problems are identified. One was related with the performance, a little more slow and difficult to select the word, because the user finger is on the letter, blocking the user see if no other letter was included by mistake. Another problem is when the user will fill the form the virtual keyboard takes up part of the screen covering part of the fields; similar has happed on the smartphone (Fig. 4a).

Another problems was identified when executed the OER in the smartphone: i) the user have difficult to read the phrases and ii) to select the found word, a very difficult goal to perform due the size and the finger over the letters, so difficult that it is very hard to mark a word. Maybe using a zoom feature can decrease the severity of these problems, but this feature is not implemented in the application either in the Flash player. It was detected a performance problem when the user drag the found word and drop it in one of the blank spaces. To reach the goal the user needs to wait some time before release the word over the blank space.

The third analyzed resource was "*Causos e Falas – Episódio 3: A chegada do filho*" (Stories and Speeches - Episode 3: The arrival of son), catalogued as simulation/animation, that the user needs to interact with personages and answer questions. For each correct answer the user wins an object that can be used to construct a cartoon. The resource goal is check understanding of preconceptions of language, realizing that the Portuguese language was influenced by the words of other languages. This resource is very similar as the last one, with a form in a home screen with three fields (to fill with the name, class and date, but only the name is required) (Fig. 5a) and an introduction text (Fig. 5b). After the introduction text, it will be displayed the party environment (Fig. 5c), where the user can select some personages to interact (only with personages whom have a balloon near), or navigate between the house clicking in the blue arrows. If the user reaches the end of the room, the respective blue arrow disappears to avoid the user to do a command without result. When the user clicks on a personage with balloon a text will be presented and after a question about it (Fig. 5d). In the smartphone the text is legible; the font size is not too small. One usability problem found is that the blue arrows do not be hidden when the user reach the end of the room; so in the smartphones the user can think that are more space and try to move again (Fig. 6). Another identified problem is to trigger the buttons due their size.

4.1 Discussion

We noticed that the position of all OER´s interface elements continues with the same appearance and location, which, in terms of usability, it is positive because maintain the consistence.

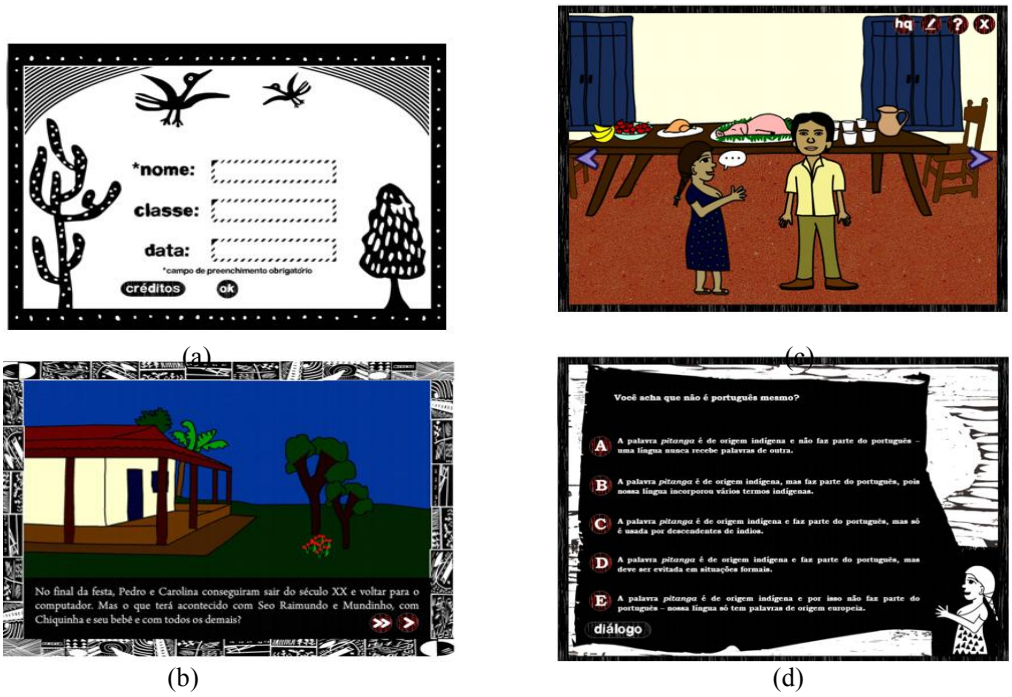


Figure 5. Educational resource "Stories and Speeches - Episode 3: The arrival of son" executed in a desktop computer: (a) home screen; (b) introduction screen; (c) the party environment screen; (d) the question screen.

Summarizing, a total of 10 problems are described in the three analyzed OER: i) the font size is to small to read on smartphones; ii) difficult to trigger features in elements with small height or width; iii) some plataform characteristics are not respect, e.g., use of gesture; iv) problem to trigger mouse point over interactions; v) the resources do not consider the rotation of the screen, working only on landscape format; vi) low performance in some devices; vii) virtual keyboard or other platform element can cover part of the resource screen; viii) the finger can obstruct user vision when she touch the screen; ix) it is not possible to use zoom; x) elements cannot have the expected behavior when is associated with other changing (it is necessary to analyze the code to confirm this hypothesis).

We believe that most of them are not a barrier for the use, but can prejudice the learning process, since can get the user nervous or anxious due the lack of performance or efficiency (many tries is necessary to trigger the action) and, sometimes, the text are too small and it is not possible to use zooming features. Some studies with volunteers answering satisfaction questionnaires can aim to probe this relation.

Based on these results, we identify two classes of problems related to portability: i) technical problems related with the device characteristics, such as the performance; ii) integration problem between the technology used to develop the resource (Flash), the Flash plugin to execute the file and the operating system (Android) that does not reflect the action of pinching fingers. The second category of problems cause strangeness with mobile users which make constant use of the feature (e.g., zooming), since she will be unable to identify the cause of the non-functioning in this particular context.

Figure 6. Educational resource "Stories and Speeches - Episode 3: The arrival of son" executed in an Android-based smartphone: (a) the party environment screen; (b) the question screen.

Even in Android-base device is not easy to run an OER developed in Flash. The user needs to install the Flash plugin and a player application. The user can use the player application and select the Flash file or use a file browser application to go to the folder and execute the correct file. Before the select the OER to run, it is necessary to download de OER file and extract it, since most of the content available at the studied portal are compacted. So an application to extract the files needs to be installed too. These steps can be difficult for mobile users, since the model of trigger applications in mobile phones is very different. Mobile users use specific application (e.g., Play Store in Android) to search and install new applications.

5. CONCLUSION

Open Educational Resources (OER) are freely accessible, openly licensed hypertext, audio, video, simulations, games and animations that are useful for teaching and learning purposes. In this paper we analyzed three educational resources catalogued as simulation/animation and accessed them in two Android-based mobile devices, a smartphone and a tablet, to identify problems that resources´ developers need to take account to produce resource for be accessed in desktops and mobile devices. More three resources were analyzed but, due the limitation of pages, we presented the most significant ones.

In our research we found problems related with performance, text legibility and trigger actions in small objects. Other identified problems are related with the finger covering part of the screen and in the object that have features triggered when the mouse pointer is over. Lack of integration between the application and the mobile devices was detected: gesture and rotation do not work.

It is important to consider that the input modality is different between desktops (keyboard + mouse) and mobile devices (touch screen) and this changing impact on the user satisfaction. The two volunteers related that the OER they liked least was Voices of the City Show – Strange Event, the second OER presented. The reasons were: i) the small screen turning hard to read and to select the words, and ii) low performance in the smartphones. The volunteers point out that this OER was the most difficult to play. To increase the adoption of educational resources in mobile users we believe that, beyond identify and mitigate usability problems, the search mechanism of content portals needs to be closer to the model adopted in mobile devices for install new applications and a mechanism to easily run the resource.

Future work will be analyzing the collected data collating with the concept of Responsive Design (Marcotte, 2011), mainly investigate the relation between the input hardware and the guidelines proposed by Responsive Design literature. Responsive Design can aim multi-devices OER giving the user an optimal viewing experience but the interaction goes beyond; it is necessary to consider the input hardware. We were interested in study which technologies make the OER support many input modalities.

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