Personalized Interactive Video-Based Crosmedia Informal Learning Environments from iTV, PC and Mobile Devices – The Design Challenges

Alcina Prata[1](✉) and Teresa Chambel[2](✉)

[1] Superior School of Business Management (ESCE), Polytechnic Institute of Setúbal, Setúbal, Portugal
Alcina.prata@esce.ips.pt
[2] Lasige, Faculty of Sciences, University of Lisbon, Lisbon, Portugal
mtchambel@ciencias.ulisboa.pt

Abstract. Television always had an important role in everyday life. However, due to several circumstances, as the proliferation of new devices with improved technological characteristics, better interfaces and better communication features, the TV viewing/use paradigm evolved to a new level. Television is now often used as part of crossmedia systems, thus creating flexible solutions so helpful when learning environments and different contexts of use are the main goal. This paper briefly addresses the design challenges that need to be considered in the design of crossmedia systems able to generate personalized video-based interactive informal learning environments from iTV, PC and mobile devices. The system that was designed to illustrate our research, and which evolved from previous versions, is called eiTV (meaning interactive TV content extended and complemented with web contents) and generates a crossmedia personalized informal video-based learning environment, through the form of a web-based content, which provides extra information about users' selected topics of interest while watching a specific video. The web content may be generated, accessed and personalized through iTV, PC and mobile devices and, depending on the users' needs, viewed immediately or stored for latter view, individually or simultaneously, also from iTV, PC and mobile devices.

An evaluation, with the participation of 90 elements, from 18 to 65 years old, grouped into 3 different age groups, was carried out with high fidelity prototypes and the achieved results were very optimistic considering that they helped rethink our crossmedia related assumptions and showed that the exploration of new functionalities and solutions was a success amongst the different age groups.

Keywords: Television · Crossmedia · Transmedia · Informal learning · Learning environment

1 Introduction

Our world is an increasingly crossmedia world. In fact, crossmedia and transmedia systems, environments and applications are prospering in practically all areas [1–3].

M. J. Abásolo et al. (Eds.): jAUTI 2020, CCIS 1433, pp. 89–104, 2021.
https://doi.org/10.1007/978-3-030-81996-5_7

Crossmedia systems refers to those where the same message is distributed through different channels/platforms (repetition) while on transmedia systems, the message is expanded through different devices/platforms (expansion) [1, 2]. The success and adoption of crossmedia and transmedia environments is impacted by many factors as for instance the proliferation of new and appealing devices capable to support human activities across different contextual settings, technological advances as faster internet access, viewers changes in terms of technological interests and habits (mainly triggered by the appearance of some killer applications as social networks) and the systems characteristics, which the most relevant are, flexibility and mobility, so essential to support today's lifestyle [3]. One of the areas where crossmedia and transmedia systems has been achieving very good results is the area of informal learning environments and contexts [4–6].

In what relates to the medium used to support learning through crossmedia systems, video is, clearly, one of the richest ones. As to the devices used to access video, TV, PC and, more recently, mobile devices, are the privileged ones depending on the age range. Through structure and interaction, these devices can open the door to flexible environments that can access video and integrate it with different media, accessible from different devices, adequate to support different cognitive modes and learning processes in several contexts. Despite their valuable potential to create rich and flexible environments, the design of these crossmedia environments/systems faces some challenges that may affect their effective use. More important than technical details are crossmedia conceptual aspects such as interaction and service design based on cognitive processes, usability, user experience, contextualization, continuity, media affordances, and device characteristics. Our main concern has been to focus also and mainly on these aspects, while studying and understanding this emerging paradigm, where research has not been complete [7].

Our eiTV system has been designed and developed to illustrate our research and has been through an evolution process of 3 generations of prototypes, all ranging from low to high fidelity prototypes. The third generation prototypes, briefly presented in this paper, were the richer ones in terms of devices and functionalities involved, which increased to match a more flexible perspective. Running from iTV, PC and mobile devices, it provides users with the possibility to choose, from a video, usually watched in a more experiential cognitive mode (which allows us to perceive and react to events naturally), which topics they would want to know more about. They may also choose with which level of detail, and later decide when and where they would want to access those extra related contents (informal learning environments, generated from iTV, PC and mobile devices, presented through the form of a web-based content), in a more reflective mode (the mode of thought), and with whom they would want to share them with, having the adequate support from the application in the different access contexts. Important to refer that, to simplify, the mentioned generated web-based extra related content, also referred to as crossmedia informal learning environment, will be referred along the text, simply, as web content. The architecture and the main features available in iTV, PC and mobile contexts were already explored and described on previous publications [4, 5, 8], but never tested as a whole and completely integrated system by three different age ranges, as presented on this paper.

After this introduction, Sect. 2 includes a review of related work and concepts, Sect. 3 describes the design challenges of crossmedia applications in that context, Sect. 4 presents some of the most important design decisions, Sect. 5 describes the evaluation process and, finally, Sect. 6 presents the conclusions and perspectives for future research and developments.

2 Related Work

This section addresses some of the more relevant related research studies in Crossmedia environments that include the same or similar devices and/or have informal/formal learning goals.

The TAMALLE project [9] developed a 'dual device system' for informal English language learning, based on watching iTV and selecting what to access later on mobile phones. This was an interesting system capable to accommodate different cognitive modes and different contexts of use, especially, if considering the mobile phone possibilities. Obrist et al. [10] developed a "6 key navigation model" and its interface for an electronic program guide running on the TV, PC and mobile phone. The different devices were not used in a complementary way since the intention was to test a similar interface, on three different devices. They have perceived that viewers prefer a reduced number of navigation keys and a unified UI with the same functionalities across devices. This confirmed our prototypes UI design last decisions. Newstream [11] provides extra information about what is being watched and related websites, using TV, PC and mobiles. Depending on the viewers' needs, that extra information may be viewed immediately, stored for later view or pushed to other device. Each device maintains awareness of each other and are able to: move interaction to the device that makes the most sense in a specific context, use several devices simultaneously, and use the mobile device as a remote to the TV and PC. Limitations include: the system relies almost exclusively on social networks to receive and share content, for interaction and dialogues; and the limited viewer direct influence on the new contents presented as extra information. Our work is more flexible in these concerns. 2BEON [12], currently called WeOnTVis, an iTV application which supports the communication between viewers, textually and in real time, while watching a specific program. It also allows viewers to see which of their contacts are online, which programs they are watching, and instant messaging on the iTV, demonstrated to be important to give viewers a sense of presence and was implemented with smartphones as "secondary input devices". This work demonstrates the importance of sharing information with viewers' contacts about what they are watching on TV, which supports our own decision of including a sharing functionality in eiTV. Cronkite [13] provides extra information to viewers of broadcast news. While viewers are watching a news story, they feel the need to know more about it, they press the "interest" button on their remote and the system provides them with extra information on the computer display. The extra information, is about the story that they are watching rather than specific topics of interest inside the story, which is somehow limited. To have the system working, both TV and PC need to be simultaneously on. The system is limited considering that the extra information is not stored for latter view (and that might be the viewers' preference). Our application stores the related information for later use, the simultaneous use of iTV and PC is a possibility but not the only option, viewers may select very specific topics of interest inside a story instead of the whole story and some specific functionalities, as asynchronous communication tools, were also contemplated.

3 Crossmedia Design Challenges

This section describes the key aspects, cognitive and affective, that need to be considered to effectively design crossmedia environments and interfaces, with a special focus on the design challenges associated with video and different devices.

Media and Cognition: Norman's view [14] defines two fundamental cognitive modes. The experiential mode allows us to perceive and react to events naturally and without cognition, but require different technological support, and the medium affects the way we interpret and use the message and its impact on us. To exemplify, TV and video are typically watched in an experiential mode while learning strongly relies on reflection. A successful integration of media should have into account what each medium and device is most suited for in each context of use, augmenting and complementing their capabilities in a flexible combination.

Crossmedia Interaction, Conceptual Model and User Experience: The main challenges of crossmedia interaction design described by [15] include: consistency, interoperability, and technological literacy needed for the different devices. The conceptual model, how the software will look like and act, is also a very important aspect since several interaction scenarios and contexts are involved [16]. The quality of the interaction cannot be measured only by the quality of the system parts, but as a whole. In this context, the user experience (UX) may be evaluated through how well it supports the synergic use of each medium and the different kinds of affordances involved, also understanding what makes the user pass the current medium boundaries to use other media as well. According to [17], the UX may involve the isolated perception of the medium (distributed), one of the biggest barriers to its efficient use and adoption, or the perception of the system as a whole unity (coherent). According to [10], the UX evaluation methods and measures relevant, when ubiquitous TV is involved, are: physiological data; data mining, log files, observation, case studies, lab experiments, experience sampling method, probes, diaries, interviews, surveys and focus groups. The combination of methods to use depends on each specific case.

Supporting Crossmedia HCI: In this context, the migration of tasks is supported via crossmedia usability and continuity, influencing on how well and smoothly users' skills and experiences are transferred across the different devices [18] and contexts of use. The consistent look and feel across media is an important requirement, even if it should not limit the goal of having each medium doing what it is most suited for and extending its characteristics (synergic use) [19].

Designing for Different Devices and Contexts of Use: Crossmedia design involves designing interfaces for different devices. To understand the devices, and have each device doing what it is most suited for, the best approach is usually to study each particular situation, including device characteristics and cognitive and affective aspects associated to its use: why people use them, in which mode, compare them, etc., and the design guidelines for each device [8] followed by an adequate combination.

4 Crossmedia Design in eiTV

In brief, this Section presents main functionalities and design options concerning the eiTV Crossmedia system, in response to the challenges identified in Sect. 3.

4.1 eiTV Architecture

The eiTV system is a portal aggregator of all the functionalities which may be accessed from any of the devices (iTV, PC and mobile phones) thus working as a true 'ecosystem of devices' in a client-server architecture. Through the portal we may: generate web contents; see, edit and share web contents (with persons with or without a portal account), upload files, change profile, etc. In sum, everyone may receive web contents generated by the eiTV, a characteristic that provides **flexibility** to the application.

4.2 Flexible Navigation Model

We opted for a menu style navigation which provides **users** much more **control** over their choices, considering that all the functionalities may be accessed at any moment, directly through the menu or through the chromatic keys. This model improves: the application **interoperability** since it shows people how it works (what functions it supports and how); the **user experience** which becomes more **coherent** considering that users easily perceive the system as a whole unit; the **crossmedia interaction continuity** through different devices and the **interaction consistency** considering that it becomes easier to reuse users interaction knowledge. Due to its **flexibility** this model is also more adapted to changes **in cognition modes,** levels of **attention** and technological **literacy.** As to the interfaces they are simpler, have a minimalist aesthetic and were designed based on each device characteristics and the guidelines.

4.3 eiTV Functionalities

a) The **Create** central functionality allows users to watch videos and select topics of interest for further information. The information available about the video differs in focus and scope (video content and video Meta-info). Both types of information were made available on the three proposed *levels of information*, from less to high informative: level 1 (topics) only implies the use of the *OK* button in order to select topics of interest; level 2 (summary) implies the immediate display of extra information as a brief summary about the topics (overlaid or embedded onscreen); level 3 (structured) implies the immediate display of extra information, namely a structured list of that topic main aspects or options that the user may choose from (overlaid or embedded onscreen). At any moment, the user can change between levels of information by pressing button 1, 2 or 3 or by using the directional buttons or by using the mouse or touch screen (depending on the device being used to create the web content). Thus, the eiTV navigation is adaptable to users with different technological **literacy**. It was decided to maintain the 3 levels of information, with embedded and overlaid options on levels 2 and 3, since we saw from the previous prototypes, that they play an important role to accommodate viewers' changes in **cognition modes**, levels of **attention**, **goals**, **needs** and interaction **preferences**.

- WebContent: My input
- Each web content is organized as follows. The left side menu contains all the topics selected by the user, presented by the order of selection in the video, to improve contextualization, but the user may choose to see them by alphabetical or logical (content dependent) order (see Fig. 1a). Sub-categories of the topics are presented in the top menu. The web content is presented inside a 'portal' which also has all the other functionalities: Create, Search, Share, Profile and DF. The Search functionality also allows the upload of information to a specific web content. Thus, bellow the selected topics presented on the left side menu, there is the 'My input' place where all the manually uploaded information is stored (text, pictures, etc.) (see Fig. 1b). This option was designed to take advantage of each **device characteristics** in order to provide **flexibility**.

Fig. 1. eiTV Web content Interface. Three types to organize all the selected topics (a); My input place in the web content (b); one of the web content editing possibilities (c)

- WebContent: editing
- Each web content has the possibility to be edited. This edition ranges from *uploading* textual information (if through the TV set) or textual information and files (if through PC or mobile devices) or GPS coordinates (if through the mobile), to *delete* the web content, a topic of the web content, a category from a specific topic or even just a simple paragraph (see Fig. 1c). This option was designed to provide users with **flexibility**, **control**, **autonomy**, **consistent interaction** and to take advantage of each **device characteristics** and **user experience**.
- WebContent: Contextualizing
- **Continuity** and **contextualization** (see Fig. 2) was supported via the use of some excerpts from the original video, namely the excerpts that were being watched in the moment of the topic selection. By default, when reaching the web content, users are positioned in the first chosen topic and the first thing that they see is the excerpt of the video that was being watched when the topic was selected (option 1 includes the video playing and option 2 includes the video paused). With these two options, we expected to gain a better understanding of which one is the preferred option to help creating a smooth transition with a good **contextualization**. On previous evaluations a third option relying on the presentation of a picture from the moment of the topic selection was made available. However, considering that it was the less appreciated option, it was not implemented this time.

Fig. 2. Contextualization in crossmedia navigation

b) The **Search functionality** allows searching videos based on different criteria. Video criteria: title, actor name, etc.; and system criteria: video with or without web content(s) already generated. The found videos are presented in a table which let users know the video title, series, episode number, if the video is in the BOX, if the video is available through VOD and if a web content was already generated. By choosing one of these videos, users will be presented with the video synopsis and choose between watching the video, editing the web content (if there is one) or simply going back. This provides **flexibility** to the system.

c) The **Share** functionality is activated only after users accessed the Create or Search functionalities. This makes sense considering that viewers could not share something that was not yet created or found. The share functionality allows sharing the generated web content or retrieved video (with or without web content), with their contacts. On this functionality **flexibility** and **error prevention** were improved.

d) The User **Profile** functionality allows to upload users' personal data from their social network thus helping users with less **technological literacy**; allows to validate the input information; present clear and unequivocal error messages; consider all possibilities (forgot the PIN or password, need to create a new account, etc.). Considering that users do not like to input too much written information, the number of items to fill in are reduced to the minimum possible (name, sex, age, e-mails, mobile number, etc.). The user profile information is used to personalize the web content, thus improving **flexibility.** The login feature (designed based on each **device characteristics**) was also adapted to the access from PCs and mobile devices in a uniform and consistent way. In a web interface to have just a PIN number (as it happens on TV) is not enough. Thus, in order to assure a secure access in a uniform and consistent way, when accessing the portal through these devices, the viewer will be asked to enter an e-mail and a PIN number.

e) The **DF** functionality was designed to have each device doing what it is most suited for. In order to achieve this goal, contexts of use, device characteristics and cognitive and affective aspects associated to the devices use, were studied. In the case of mobile devices functionalities, the following were made available:

- *Great flexibility and mobility* (use it everywhere, anytime, anyway):
  When using the TV, the scroll is not an option, but that does not happen when using the other devices; contrary to TV and PC, mobile devices may be used everywhere, even when users are standing up, mining that any extra time may be used (if waiting for a medical appointment, in a bus queue, while in the train, etc.);
- *Location-based search using the GPS functionality*:
  the search functionality allows users to search videos related to their current location. As an example, when near the liberty statue the user may use this functionality to search, from its own system and the internet, videos related to that specific spot (this type of video files need to be inserted when using iTV or PC) (see Fig. 3);

- *Add immediately, or latter, shot pictures or videos,* that may be *related,* to the video being watched, as additional information to the web content or, instead, really integrated as part of the web content.

These functionalities provide the system with **flexibility**.

Fig. 3. Search videos and images from GPS coordinates. Video capture and location-based search: a) Options available at the DF functionality and 'Video' option being activated; b) Possibility to choose from a video gallery or to record a new video. The viewer choice was to record a new video; c) The viewer is choosing to search related videos and images by GPS coordinates; d) The two results – one video and one photo recorded in very close places - appear as thumbnails embedded in the video just recorded. A simple click on the video allows to watch it.

f) The **Devices Synchronization** functionality - The possibility to synchronize devices was designed and implemented in order to allow the application to work as a true ecosystem of devices. Figure 4 illustrates this option via mobile phone. When accessed through PC and TV, the same interfaces are available. Only the interface presented in Fig. 4a) changes considering that 'Add GPS coordinates' is a mobile phone specific option.

Fig. 4. eiTV Devices Synchronization. Synchronizing devices: a) Options available at the DF functionality and ‘Devices Synchronization’ option being selected; b) Automatic detection on the connected interfaces. Viewer use the phone button in order to activate the menu to choose to which device synchronize his mobile; c) In this case is choosing PC (the only device on).

Consistency in UX and the perception of the system as a whole coherent unity independently of the device being used was also a priority. In spite of having considered the mobile device characteristics and contexts of use in the design, towards a more simplified design, we decided to keep a coherent layout in terms of colours, symbols and other graphic elements, as navigational buttons, in order to better contextualize users, give them a sense of unity in their UX and to allow a smooth transition among media and devices. This way, it was possible to provide users with a sense of sequence and continuity, respect the context of use and be consistent in terms of look and feel and navigational options in all the devices, and to help the perception of the application as a unity. Users are aware that they may access their eiTV system through different devices whenever they create web contents, helping to conceptually understand the system as an ‘ecosystem of devices’. An example of the resulting design interface is presented in Fig. 5.

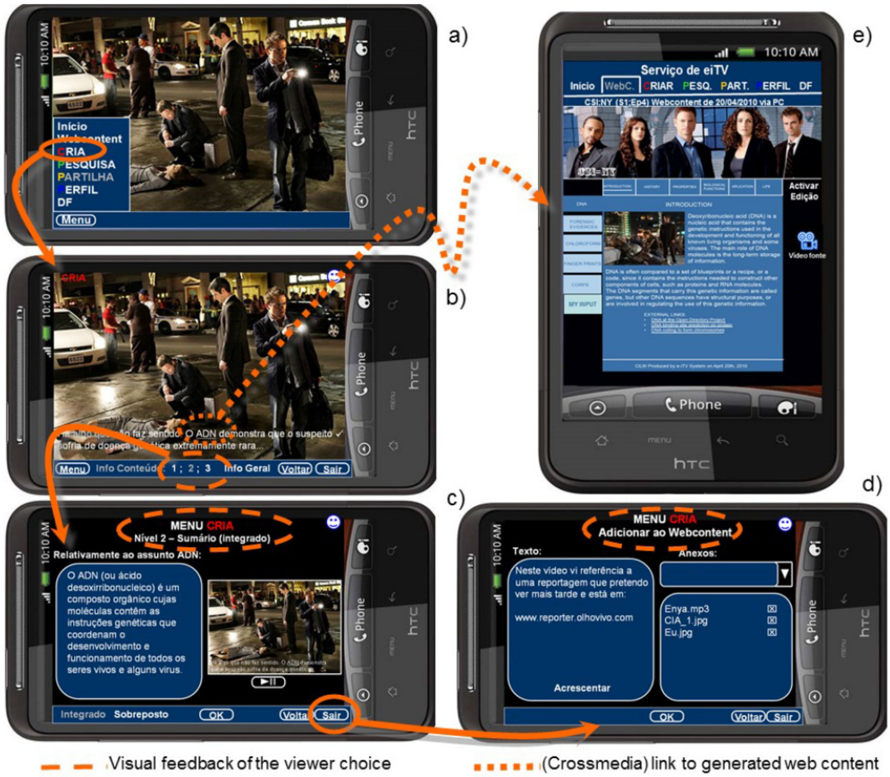

Fig. 5. eiTV Mobile Interface *Create* functionality (a); topics selection interface with the information level 2 activated (b); aditional information immediately presented when a topic is selected by the user and the information level 2 is activated (c); interface to the addition of files captured on the moment to the web content being created (d); interface of the generated web content, based on the users selected topics (b–e)

5 Evaluation

The UX evaluation methods and measures considered relevant for this specific case as a final evaluation were: observation, case studies, lab experiments, experience sampling method, questionnaires, interviews and focus groups. The evaluation process started with a demonstration of the high-fidelity prototype using all the three devices involved (iTV, PC and mobile) and all the functionalities. Then, users were asked to perform tasks that allowed using all the eiTV functionalities (central and devices specific ones), through the prototype in five different contextual scenarios, and devices, with transitions between them. At a simulated 'living room' environment, Users started using the prototype, by generating two different web contents, first through iTV, and next through PC. The web content 1 was created through TV and edited/personalized via TV; web content 2 was created via PC and edited/personalized via TV. Next, they moved to the school bar and edited and personalized the web contents 1 and/or 2 via mobile. Next, they generated web content 3 through mobile while seated at the school bar. Then, they moved to the school backyard, created a video, and searched related videos by GPS coordinates (*Location-based search using the GPS functionality)* which were added to the web content to personalize it. Then, they entered the school and, at the lobby, used the mobile to take a picture, add the metadata manually, and add the picture to the web content. Next, they moved to the bar and, standing up at the end of the bar queue (like other public queues), they personalized the web content with their GPS coordinates. Next, they moved to the library that, although surrounded by people, is a quiet place (context like a medical clinic waiting room) to view the final web contents. Finally, they moved to the 'living room' and viewed the three final web contents using all the devices. Note that during the changes of context, the luminosity conditions, as well as the surround conditions (noise), changed when going from the building interior to the exterior, and vice versa. The interaction with the GUI high-fidelity prototype occurred via the three devices. It is important to mention that the evaluation process took place in real contexts of use, one of the most important factors to consider when testing crossmedia environments.

Finally, viewers were asked to fill a questionnaire and were interviewed. The questionnaire was based on the USE questionnaire (usefulness, satisfaction and ease of use) [20]; the NASA TLX questionnaire (cognitive overload) [21]; and usability heuristics. There were 90 participants, ranging from 18 to 65 years old, which were grouped into 3 evaluation groups: group 1 (G1) composed of 30 students aged between 18 and 25; group 2 (G2) composed of 30 persons aged between 25 and 45 and group 3 (G3) composed of 30 persons aged between 45 and 65. Inside each group the participants were categorized as follows: 10 with high technological literacy; 10 with medium technological literacy and 10 with poor technological literacy. No one ever participated on previous evaluations. As to the participants technological literacy categorization, it was possible via the use of a questionnaire with questions as: do you use Internet? e-mail? Facebook? How many hours a day? From which devices? Do you have a smartphone? Which functionalities do you use on your smartphone? etc.

Results are presented next. Independently of the group (and thus, age), medium and high technological literacy categories reacted well to difficulties. However, when considering low technological literacy categories, it was possible to see that, in the presence of difficulties, G3 reacted with higher resistance and discouragement than G2 and G1. In what relates to the iTV interaction, G2 and G3 were the ones with higher facility, which is visible by the results presented on Table 1, where we can also see the preferred devices to generate the web content. As expected, the older generation prefers the iTV to generate the web content (60%), while G2 prefers the PC and the youngest prefer the mobile. This may be explained by an increase in the use of cable TV options and applications as Netflix. Thus, older generations are becoming more and more used to interact even through iTV while younger generations, in spite being very used to interact, are becoming very distant from iTV (due to a change in their video consumption habits which are traditionally mobile based).

In what relates to the preferred devices to access and personalize the web content we can see from Table 2 that the mobile device was the preferred in all groups. In spite preferring the iTV to generate the web content, the older group (G3) prefers the mobile to access and personalize it thus clearly valuing the mobility that a smartphone brings to the system.

Table 1. Preferred device to generate the web content

Device to generate the Web content	G1	G2	G3
iTV	20%	37%	**60%**
PC	43%	**50%**	33%
Mobile	**37%**	13%	7%

Table 2. Preferred device to access and personalize the Web Content

Device to access de Web Content	G1	G2	G3
iTV	0%	7%	**13%**
PC	10%	10%	27%
Mobile	**90%**	**83%**	**60%**

In terms of information level, more users preferred level 1 (the less intrusive and less informational) if from mobile, level 2 is the preferred from iTV and level 3 is the preferred from PC. This result stresses an increase in users preference to select additional info to access later on when they are watching video on PC and iTV. These results are contrary to previous studies, which revealed that the preferred level for interaction was on the move with a mobile, when compared with.

TV or PC, where users preferred not to interrupt a more experiential mode of watching videos. These results, which are in accordance with the ones presented on Table 1, may indicate a changing in paradigm, and that independently of the device being used users are becoming more and more used to interact, even when through iTV. One explanation may be the fact that the information level 2 is very similar to the Video on Demand and/or Netflix synopsis option.

In terms of specific mobile devices functionalities, namely, the '*Location-based search using the GPS functionality'* and the '*Add immediately, or latter, shot pictures or videos*' the results of the evaluation are presented on Table 3.

Table 3. Evaluation of specific mobile devices functionalities

	G1	G2	G3
Useful	94%	90%	91%
Easy to use	97%	93%	91%
Easy to learn	97%	92%	83%
Like to have it	99%	94%	87%
Recommend to a friend	98%	90%	91%

As somehow expected, G1 was the group more enthusiastic with these functionalities. It makes sense if considering that the youngest population is the one that spends more hours per day using mobile devices. G2 results were slightly lower. As to G3, the results were even lowest but not so low as expected, which is a good indicator that this group has facility to adapt to mobile devices functionalities.

As to the *Devices Synchronization* functionality it was considered useful (G1: 97%; G2: 91%; G3: 98%) and easy to use (G1: 98%; G2: 93%; G3: 97%) in all the groups which is a very good indicator.

It is important to mention that the intention of transmitting a sense of unity was achieved: G1: 93%; G2: 87%; G3: 73% and, in general, 93% of the users referred that they immediately felt "inside" the same application, despite using different devices. As a whole the eiTV crossmedia system was evaluated as presented on Table 4.

Table 4. Overall evaluation of the whole eiTV crossmedia

Whole application	G1	G2	G3
Useful	93%	90%	70%
Easy to use	87%	83%	63%
Easy to learn	83%	80%	63%
Like to have it	93%	87%	67%
Recommend to a friend	97%	93%	83%

As can be seen, the evaluation of groups G1 and G2 are very close which was somehow expected. This indicates that the G1 has higher propensity to the use of (specific) technology, due to their young age, is bridged by G2 years of technology use experience. As to the G3 results they are very good if considering that is the oldest group and the worst obtained classification was 63% meaning that 19 out of 30 persons found the system easy to use and easy to learn. In spite a good start, a lot must be done in terms of Interfaces design research to adjust them to older populations.

6 Conclusions and Future Work

The evaluation results were very encouraging. In many aspects, the designed functionalities and the system flexibility were perceived as useful and an added value in the crossmedia research area. Some design options allowed to accommodate the changes in users' cognitive mode (e.g., information levels), and the prototype was designed and tested in real mobile scenarios and contexts of use. Considering the design framework followed, the trends in the use of multiple devices, and the results of this and previous studies, we have reasons to believe that our goal for this crossmedia context is worth pursuing and that we can achieve quite good results with all the devices in different scenarios. As future work, we intend to explore the devices technological advances to create new functionalities capable to better support users needs and different cognitive modes. A continuous improvement of the interfaces, so they may become easier to learn and adopted by an elderly population, is also a goal.

Acknowledgments. This work is partially supported by FCT through LASIGE Multiannual Funding and the ImTV research project (UTA-Est/MAI/0010/2009). To Diogo Silva, for his collaboration in the development of the first generation eiTV prototypes.

References

1. Gambarato, R.: Crossmedia, Multimedia and Transmdia. Published on 20 of October 2020. https://www.youtube.com/watch?v=G3wdbajO6js. Accessed 30 Nov 2020
2. Moloney, K.: Multimedia, Crossmedia, Tranmedia… What's in a name? Published on 21 of April 2014. https://transmediajournalism.org/2014/04/21/multimedia-crossmedia-transmedia-whats-in-a-name/. Accessed 30 Nov 2020
3. Jenkins, H.: Transmedia Missionaries: Henry Jenkins. Published in 23 of July 2009. http://www.youtube.com/watch?v=bhGBfuyN5gg. Accessed 19 Nov 2020
4. Prata, A., Chambel, T.: Mobility in crossmedia systems, the design challenges that need to be addressed. In: Abásolo, M.J., Kulesza, R., PinaAmargós, J.D. (eds.) jAUTI. CCIS, vol. 1202, pp. 67–86. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-56574-9_5
5. Prata, A., Chambel, T.: Mobility in a crossmedia environment capable of generating personalized informal learning contents from iTV, PC and mobile devices. In: Proceedings of JAUTI 2019 – VIII Conferência Iberoamericana sobre Aplicações e Usabilidade da TV Interativa, Rio de Janeiro, Brasil, pp. 59–71 (2019)
6. Bonometti, S.: Learning in cross-media environment. Int. J. Web-Based Learn. Teach. Technol. **12**(4), 48–57 (2017). https://doi.org/10.4018/IJWLTT.2017100105
7. Taplin, J.: Long time coming: has interactive TV finally arrived?. Opening keynote. In: Proceedings of 9th European Conference on Interactive TV and Video: Ubiquitous TV (EuroiTV 2011), in coop with ACM, Lisbon, Portugal, p. 9 (2011)
8. Prata, A., Chambel, T.: Going beyond iTV: designing flexible video-based cross-media interactive services as informal learning contexts. In: Proceedings of 9th European Con-ference on Interactive TV and Video: Ubiquitous TV (EuroiTV 2011), in coop with ACM, Lisbon, Portugal, pp. 65–74 (2011)
9. Pemberton, L., Fallahkhair, S.: Design Issues for Dual Device Learning: interactive television and mobile phone. In: Proceedings of 4th World Conference on mLearning - Mobile Technology: The Future of Learn in Your Hands (mLearn 2005), Cape Town, South Africa (2005)
10. Obrist, M., Knoch, H.: How to investigate the quality of user experience for ubiquitous TV?. Tutorial. In: Proceedings of EuroiTV 2011, 9th European Conference on Interactive TV and Video: Ubiquitous TV, Lisbon, Portugal (2011)
11. Martin, R., Holtzman, H.: Newstream. A multi-device, cross-medium, and socially aware approach to news content. In: Proceedings of 8th European Interactive TV Conference (EuroiTV 2010), in coop with ACM, Tampere, Finland, pp. 83–90 (2010)
12. Abreu, J.: Design de Serviços e Interfaces num Contexto de Televisão Interactiva. Doctoral thesis, Aveiro University, Aveiro, Portugal (2007)
13. Livingston, K., Dredze, M., Hammond, K., Birnbaum, L.: Beyond broadcast. In: Proceedings of ACM IUI 2003, The Seventh International Conference on Intelligent User Interfaces, Miami, USA, 12–15 January 2003, pp. 260–262 (2003)

14. Norman, D.: Things that Make us Smart. Addison Wesley Publishing Company, Reading (1993)
15. Segerståhl, K.: Utilization of pervasive IT compromised? Understanding the adoption and use of a cross media system. In: Proceedings of 7th International Conference on Mobile and Ubiqitous Multimedia (MUM 2008) in cooperation with ACM SIGMOBILE, Umea, Sweden, pp. 168–175 (2008)
16. Norman, D.: The Design of Everyday Things. Basic Books, New York (2002)
17. Segerståhl, K., Oinas-Kukkonen, H.: Distributed user experience in persuasive technology environments. In: de Kort, Y., IJsselsteijn, W., Midden, C., Eggen, B., Fogg, B.J. (eds.) PERSUASIVE 2007. LNCS, vol. 4744, pp. 80–91. Springer, Heidelberg (2007). https://doi.org/10.1007/978-3-540-77006-0_10
18. Florins, M., Vanderdonckt, J.: Graceful degradation of user interfaces as a design method for multiplatform systems. In: Proceedings of the ACM International Conference on Intelligent User Interfaces (IUI 2004), Funchal, Madeira, pp. 140–147 (2004)
19. Nielsen, J.: Coordinating User Interfaces for Consistency. Neuauflage 2002 ed. The Morgan Kaufmann Series in Interactive Technologies, San Francisco (1989)
20. Lund, A.: Measuring Usability with the USE Questionnaire. https://garyperlman.com/quest/quest.cgi?form=USE. Accessed 15 Oct 2020
21. NASA: NASA TLX Paper and Pencil Version. https://humansystems.arc.nasa.gov/groups/tlx/tlxpaperpencil.php. Accessed 01 Oct 2020