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Designing Personalized Video-Based Crossmedia Informal Learning Environments Beyond iTV

Alcina Maria Narciso Prata

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To my son, my gravity center, the light that lights up my steps along the way; to my parents for being always there for me independent of circumstances and to João, my lucky star!

In Portuguese:

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Abstract

Video is a very rich medium, in cognitive and affective terms, to convey information and support learning and entertainment like no other medium, and TV is a privileged way to watch it. However, by being traditionally watched in a more experiential and passive cognitive mode, TV and video are limited in their capacity to fully support learning so important in the lifelong learning era where learning is taking place in a wide variety of contexts and locations that calls for flexible environments. TV and video are limited in their capacity to fully support learning but may induce viewers to engage in more reflective modes, that can be supported to some extent by their adequate design, in interactive contexts and augmented by other media and devices, in diverse situations. The inclusion of iTV that has been gaining increasing attention from researchers, and practitioners, in the last few years, as part of rich and flexible crossmedia environments brings new opportunities in this respect.

This situation justifies our research main goal to efficiently and flexibly support users learning informal opportunities created in video-based crossmedia environments, taking into account the different cognitive modes, contexts of use and taking advantage of the diverse devices being used in order to have each device contributing with what it does best.

In order to illustrate, explore and validate our research, the eiTV application was conceptualized, prototyped and evaluated. It is capable to create video-based crossmedia informal learning environments, created as additional information to the video being watched, initially via iTV. These environments are accessed from iTV, PC and mobile devices (the most commonly used in crossmedia scenarios), depending on the preferred or most adequate device in each context of use.

Keywords: Crossmedia, Transmedia, iTV, Design, Video, Interaction, Informal Learning, Mobile Devices, Personalization.

Resumo – Portuguese Abstract

O Vídeo é um meio muito rico em termos cognitivos e afectivos, tanto para armazenar informação como para dar suporte à aprendizagem e entretenimento como nenhum outro. Desde cedo foram muitos os autores, dos quais Walt Disney terá sido provavelmente o mais conhecido, que lhe adivinharam um futuro risonho enquanto meio privilegiado em questões educativas. O vídeo é um meio tradicionalmente activo ou quente, induzindo uma atitude passiva ou fria nos utilizadores e, apesar de poder ser visto através de dispositivos diferentes, a verdade é que a TV continua a ser uma forma privilegiada para o ver. A TV apesar de utilizada (visualizada) num modo cognitivo mais experiencial e passivo (ou seja o modo que nos permite perceber e reagir aos acontecimentos de forma eficiente e sem esforço, o modo da percepção, entretenimento, motivação e inspiração) pode conduzir os telespectadores a modos cognitivos mais reflexivos e activos, em segundos (modo da cognição, do pensamento, da tomada de decisão, da razão). Não obstante poder conduzir os telespectactores a um modo cognitivo mais reflexivo, a TV é contudo limitada no que respeita a proporcionar um suporte adequado a este modo cognitivo, um modo muito importante na aprendizagem. Enquanto estão a ver um programa de TV, os telespectadores podem querer saber mais acerca de um determinado tópico. No entanto, podem preferir continuar num modo mais experiencial, o modo dominante quando se vê TV, e seguir mais tarde, possivelmente através de outro dispositivo e quando puderem envolver-se num modo cognitivo mais reflexivo, o caminho que os leva a saber mais sobre o referido tópico, ou podem optar por seguir esse caminho imediatamente.

A TV por si só não constitui um suporte adequado à reflexão, o modo cognitivo por excelência quando a aprendizagem é o objectivo. No entanto, apesar de não conseguir aumentar a reflexão humana neste sentido, a TV pode tornar-se numa poderosa ferramenta para reflexão quando devidamente aumentada. De facto, a televisão interactiva (iTV), dada a sua natureza, pode possibilitar aceder e interagir com a informação sobre o programa e tópicos relacionados que podem estar disponíveis como conteúdo de TV indexado e

referências para seguir e pesquisar. A história da iTV tem sido repleta de percalços que ditaram uma jornada de avanços e recuos. Mas a verdade é que, nos últimos anos, a iTV tem ganho cada vez mais atenção por parte de investigadores, operadores de TV e do público em geral, dado o seu potencial em termos de entretenimento, e também comunicação, saúde e aprendizagem, tornados possíveis através de avanços tecnológicos e um melhor design de interfaces e serviços. A iTV tem a vantagem de combinar o apelo e a audiência de massas da TV com a interactividade da web, permitindo novos serviços, dando aos telespectadores maior controle sobre aquilo que vêm e criando um ambiente novo e enriquecido. É por isso, na opinião de muitos investigadores e produtores, uma tecnologia que está a ser cada vez mais utilizada e portanto a ganhar o seu espaço. Esta convicção é claramente suportada pelo número de estudos de investigação que surgiram nos últimos anos. Alguns estudos identificaram o potencial da iTV para aumentar oportunidades de aprendizagem a partir de casa, em particular através de opções personalizadas e a necessidade de encontrar formas de utilizar a poderosa combinação da TV convencional e dos serviços interactivos, de modo a conduzir os telespectadores a ambientes de aprendizagem activos.

Outros dispositivos, como PCs e telemóveis, também evoluiram e são agora frequentemente utilizados para a visualização de vídeos. No entanto, estes dispositivos que implicam uma atitude 'inclinada para a frente' (lean forward) são mais adequados para suportar o modo reflexivo e mais activo dos utilizadores. Contrariamente, a TV (e o vídeo em especial) é caracterizada por implicar uma atitude 'inclinada para trás' (lean back), e tal como previamente referido, é mais adequada para suportar o modo cognitivo experiencial e passivo dos utilizadores. No entanto, os utilizadores podem alternar entre estes dois modos cognitivos em segundos, dependendo de diferentes tipos de factores internos e externos, e ambos são importantes para a cognição humana embora requeiram diferentes tipos de suporte tecnológico. Assim sendo, sistemas preparados para suportar mudanças nos modos cognitivos, em particular se baseados na utilização de dispositivos diferentes, são certamente mais flexíveis e apropriados às necessidades dos utilizadores. Simultaneamente, estamos a testemunhar um momento de transição, em que os velhos sistemas estão a ser utilizados de forma distinta e, nalguns casos, a morrer e a dar lugar a novos. A tradicional cultura espectatorial está a dar lugar a uma cultura participativa. E neste contexto é importante que se refira que os avanços não ocorrem apenas porque a tecnologia evolui. É lícito dizer que a tecnologia evolui porque também as pessoas modificaram a sua forma de estar e de interagir requerendo cada vez mais tecnologias que suportem a sua 'nova' forma de estar. Cada vez mais as pessoas têm demonstrado propensão para a interactividade, para a partilha e para a utilização de dispositivos em simultâneo como por exemplo, usar o PC e dispositivos móveis para interagir com a TV e para partilhar conteúdos. A proliferação de novos dispositivos capazes de suportar as actividades humanas através de um espectro alargado de contextos de uso, tal como acontece na vida real, foi uma das maiores motivações para a integração dos dispositivos naquilo que se designou por sistemas crossmedia. Estes sistemas não estão limitados a um único dispositivo, tal como o telemóvel, PC ou iTV mas, ao invés, recorrem a alguns ou até a todos os dispositivos. Os sistemas crossmedia são muitas vezes referidos como multi-plataforma ou transmedia. No contexto do presente trabalho, uma aplicação, sistema ou ambiente crossmedia é aquele que se espande por vários dispositivos como parte de um sistema único, com uma estrutura de papeis e funcionalidades definidos para atingir objectivos específicos.

A par com a proliferação de sistemas crossmedia, o acesso global à informação e às tecnologias está a mudar a relação entre pessoas e conhecimento, e a tendência para a convergência, integração e co-existência de várias tecnologias está a criar novas oportunidades para a globalização das práticas de aprendizagem e comunicação. Devido à sua flexibilidade, os sistemas crossmedia são particularmente promissores no que respeita às oportunidades que criam em termos de comunicação, entretenimento, aprendizagem e outras actividades. Com a emergência da era da aprendizagem ao longo da vida, e considerando que a aprendizagem passará a ter lugar numa grande variedade de contextos, e locais e que a aprendizagem informal (a que tradicionalmente ocorre a partir de actividades diárias, normalmente de forma inesperada) tenderá a ser tão importante como a aprendizagem formal, necessitando por isso de ambientes flexíveis, pode dizer-se que os sistemas crossmedia são um auxiliar perfeito para lhes dar suporte.

No entanto, estes sistemas, bastante promissores devido às suas vantagens e potencialidades para criar ambientes ricos e flexíveis, enfrentam alguns desafios de desenho que podem afectar a eficiência da sua utilização. Essa situação justificou o principal objectivo de investigação desta tese que foi perceber como dar suporte, de forma eficaz e flexível, às oportunidades de aprendizagem informal, criadas em ambientes crossmedia centrados no vídeo, levando em conta os diferentes modos cognitivos, contextos de uso e tirando partido dos diferentes dispositivos utilizados.

De modo a alcançar o objectivo proposto, alguns desafios de investigação necessitaram de atenção especial, como por exemplo as questões conceptuais que se relacionam com: o uso de vários media e dispositivos com características diferentes, os diferentes contextos de uso, os aspectos cognitivos inerentes a cada media e dispositivo, bem como a continuidade e contextualização da experiência de utilização através de diferentes dispositivos em tempos e locais diferentes. Neste trabalho, estes desafios são apresentados e discutidos e, com base nisso, é descrita e sugerida uma framework conceptual que refere aspectos relevantes para o desenho, a partir de vídeo, e como resposta a necessidades de aprendizagem informais, de ambientes crossmedia personalizados para acesso a conteúdos.

Concluindo, este trabalho apresenta as seguintes contribuições:

- Explora o que contribui para a análise, desenho, prototipagem e avaliação eficaz de aplicações e interfaces para serviços crossmedia flexíveis, baseados em vídeo, tirando o melhor partido de cada um dos dispositivos envolvidos. Com base na investigação efectuada e na experiência adquirida é proposta uma framework conceptual para análise, desenho, prototipagem e avaliação deste tipo de conteúdos.
- Explora o que contribui para a análise, desenho, prototipagem e avaliação eficaz de aplicações e interfaces flexíveis para iTV. Com base na investigação efectuada e na experiência adquirida é proposta uma framework.
- Como forma de exploração, validação e prova de conceito, foi desenvolvida uma aplicação, à qual foi dado o nome de eiTV, desenhada e avaliada de modo a ilustrar, explorar e validar a nossa investigação. A aplicação eiTV é capaz de criar ambientes crossmedia de aprendizagem informal, criados

como informação adicional ao vídeo que está a ser visto a partir desse mesmo vídeo e, inicialmente a partir da iTV. Estes ambientes podem ser acedidos via iTV, PC e dispositivos móveis, dependendo do dispositivo preferido ou do mais adequado a cada contexto de uso em qualquer altura, quer para visualização quer para partilha.

- Importa ainda referir que, mais do que um meio para experimentação e validação da investigação, a intenção era que a aplicação eiTV pudesse também ser vista como um novo tipo de serviço com interesse para uso generalizado em contextos crossmedia emergentes.

A avaliação, cujos resultados foram considerados bastante positivos e animadores, é igualmente apresentada e discutida, permitindo validar os contributos e identificar direcções futuras.

Palavras Chave: Crossmedia, Transmedia, iTV, Design, Video, Interacção, aprendizagem informal, dispositivos móveis, personalização.

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"The best way to predict the future is to have the power to shape it."
Philosopher Eric Hoffer

1. Introduction

Video is a very rich medium, in cognitive and affective terms, to convey information and support learning and entertainment. Since early, several authors, being Disney (1994) probably the most well-known, have foreseen the video as a privileged educational medium. In spite of being watched from different devices, TV still is a privileged way to watch it, and although being a traditionally active or hot medium, inducing a passive or cold attitude in the viewers (McLuhan, 1964), TV may guide them into different cognitive states, more experiential or more reflective, in seconds, but not usually providing an adequate support for reflection. However, interactive TV (iTV[1]) and especially in a crossmedia environment can be designed for a better support. For example, while watching a TV program, at some point in time, viewers may feel the need or will to know more about a specific issue that caught their attention. Viewers may prefer to remain in the dominant experiential mode of TV watching and follow a route to additional information at a later time and possibly through a different device, when they may engage in a more reflective cognitive mode, or explore it right away. As stated by (Chambel & Guimarães, 2000; Norman, 1993) the medium is not neutral, influencing the message and its impact on us. Broadcasted TV by itself does not provide the adequate support to reflection, especially important when learning is the goal. In spite of not augmenting human reflection in this sense, traditional TV may turn into a powerful tool for reflection when properly augmented (Chambel & Guimarães, 2002; Chambel *et al.*, 2006; Norman, 1993). In fact, iTV, by its nature, may allow the possibility to access and interact with information about the program and related issues that

[1] iTV is a TV system that allows the viewer to interact with an application that is simultaneously delivered, via a digital network, in addition with the traditional TV signal (Perera, 2002)

may be available as indexed TV content and references to follow and search. The truth is that the role that TV has been playing so far is changing. In the last few years, iTV has been gaining increasing attention from researchers, TV operators and the general public, due to its potential in entertainment, and also in communication, health, and learning, made possible by technological advances and better interface and services design. The history of iTV is full of pitfalls, which have dictated a journey of advancements and recoils (Abreu, 2007; Chorianopoulos, 2004). Nevertheless, iTV technology combines the appeal and mass audience of full motion TV with the interactivity of the web and the internet, providing new services, giving viewers more control over what they see and creating a new and very rich environment. It is, in the opinion of many researchers and producers, a technology that is increasingly being used and that will conquer its market space (Abreu, 2007; Hess *et al*., 2012; Quico, 2004). This conviction is clearly supported by the number of research studies that were conducted on these last few years. Some studies have identified a potential for the use of iTV for increasing learning opportunities in the home, in particular through personalized options (Bates, 2003) and the need to find ways of utilizing the powerful combination of broadcast TV and interactive services to provide hooks to draw viewers into active learning environments (Bates, 2003).

Other devices, as PCs and mobile phones, also evolved and are now frequently used to watch videos. However, these devices which imply a 'lean forward' attitude are more adequate to support users' reflective mode. Whereas TV, which is characterized by implying a 'lean back' attitude, is more adequate to support users' experiential and passive cognitive mode. However, users may alternate between these two cognitive modes in seconds, depending on several kinds of internal and external factors, and both are important in human cognition, but they require different technological support. Thus, systems prepared to accommodate changes in cognition modes, and especially if using different devices, are likely to be the more appropriated to users' needs.

Simultaneously, we are witnessing a moment of transition, a moment where "old media systems are dying and new media systems are being born. The traditional 'spectatorial' culture is giving way to a participatory culture" (Jenkins, 2010). The proliferation of new devices able to support human activities across a range of contextual settings (Segerståhl, 2008), just like it happens in 'real life', is one of the main motivations for media integration in what is designated as crossmedia. These systems are not limited to one single media technology, such as mobile devices, PC or iTV, but, instead, include many of them. Crossmedia systems are sometimes referred to in the literature as cross platform, cross device and, more recently, as transmedia by Jenkins (2010). Crossmedia and cross-device are the most used concepts. The term crossmedia has emerged in the context of modern communications research, spanning the fields of computing and human-computer interaction (HCI) (Wiberg, *et al*., 2007). For the purpose of our work, a crossmedia application, system or environment is defined as one that extends across a range of different devices, as part of a whole system with a structure of roles and functionalities, in order to achieve specific goals (Segerståhl, 2008).

Simultaneously to the proliferation of crossmedia systems, global access to information and technology is changing the relationship between people and knowledge, and the trends in convergence, integration and co-existence of various media technologies is creating new opportunities for the globalization of learning and communicational practices. Crossmedia systems are particularly interesting in what concerns the opportunities they create in terms of communication, entertainment, learning, and other activities (Bates, 2003). In terms of learning support, these systems are particularly promising due to the emerging era of lifelong learning, as learning will take place in a wide variety of contexts and locations and informal learning (the learning that traditionally occurs from daily activities usually in an unexpected fashion) will tend to become as important as formal learning (Bates, 2003; OECD, 2004), calling for flexible environments.

There are many advantages in crossmedia applications, especially the fact that they are already depicting the world, considering that reality is already crossmedia. In fact, reality is complex enough to allow us to have many different characters or many different stories on many different platforms. We are in the presence of different possible contexts that the viewer may experience. We can imagine the following scenario: a university student arrives from school and, after dinner, by chance, s/he comes across a documentary on TV that addresses some issues related to what s/he is studying in Biology. S/he is very interested in knowing more about a certain number of those issues. However, since s/he is in a more experiential and passive cognitive mode and does not want to break the flow of the program, the intention is to watch the program through and just select some issues along the viewing, to be accessed as extra related selected content from the mobile phone, while in the train to the university next morning, or later on from the PC, the more adequate devices when in a reflective mode. However, in spite of their inherent flexibility, there are also aspects that affect the efficient use of crossmedia applications. Most users still feel more comfortable with the typical end-user computing environment and need to acquire technological skills in order to manage several devices (Oulasvirta, 2008). This requires additional effort and there are often tradeoffs between effort and benefit (Obrist *et al*., 2010). Thus being, systems with good interfaces and useful functionalities are those more likely to engage viewers into action.

1.1. Objectives and Approach

The success of iTV, a typical device used in crossmedia systems, requires technological solutions, sustainable models and pedagogical solutions, and there is still limited research in this particular area, especially on cognitive and interaction aspects (Bates, 2003; Lytras *et al*. 2002; Prata & Chambel, 2011a). iTV has the potential to open doors to flexible environments in crossmedia scenarios, where media types are integrated and each device can contribute with its strengths to support learning, even when informal. Crossmedia applications are very promising due to their advantages and potentialities to create rich and flexible environments. However, after a detailed literature review, it was possible to perceive that some research challenges need special attention, as for instance, the use of several media and devices with different characteristics, the diversity of contexts of use, the cognitive aspects inherent to each medium and device and the continuity and contextualization of the user experience across different devices at different places and time. In fact, many of the proposed crossmedia applications failed because too much effort was put into technical details, leaving behind crossmedia conceptual questions related to: interaction design and underlying cognitive aspects, usability, affectivity, user experience, contextualization, continuity, media technology, or device characteristics. The handling of these dimensions when video is involved was our starting point and main motivation.

Our main concern was to focus on these conceptual questions, to study and understand this emerging paradigm, which success requires not only technological solutions, but sustainable models and pedagogical solutions, where research has not been complete (Prata *et al*., 2010; Segerståhl, 2008; Taplin, 2011). However, it was expected that the eiTV application, designed to illustrate our research, would also allow us to propose a new and personalized type of iTV based crossmedia service, which is, in the opinion of several researchers, the next direction to follow (Chorianopoulos, 2004; Eronen, 2004; Jenkins, 2006; 2011; Quico, 2004). As stated by (Bardzell *et al*., 2007), devices or interfaces that aggregate meta-games content in ways that help create coherent, if not seamless, game experiences represent another potential area for crossmedia interaction to improve gaming. This is also true for TV programs and videos, which benefit largely from devices and interfaces that aggregate meta-info (as extra content and additional information) in order to help creating coherent program and video watching, also aligned with our research goals.

The designed eiTV application that is described in this thesis generates crossmedia personalized web content as additional information to the video being watched (in an initial phase through iTV) in response to informal learning opportunities. The personalized web contents are prepared to be viewed through iTV, PC and mobile phones. Video was chosen as the departure media due to its richness, specific cognitive, affective and entertainment features, and also for being a dominant media component in the crossmedia domain (Chambel & Guimarães, 2000; 2002; Jenkins, 2006). TV, and in particular iTV, was chosen since it is still the preferred device to deliver and access video.

As such, the thesis main goal was to efficiently and flexibly, support users learning informal opportunities, created in video-based crossmedia environments, taking into account the different cognitive modes, contexts of use and taking advantage of the diverse devices being used in order to have each device contributing with what it does best. In order to illustrate, explore and validate our research, the approach followed was based on the conceptualization, design, prototyping and evaluation of the eiTV application. In this context the challenges, or research questions, that this thesis aims to answer are the following:

RQ1*: Which model interface design and functionalities are adequate in order to:*

a) Provide an adequate support to create and follow extra web contents?

b) Have interfaces easy to use and understand in each of all devices (usability)?

c) Create personalized web contents appropriate to give sequence and continuity to informal learning opportunities created by the visualization of the video (are they able to contextualize viewers in relation to what they first saw and provide further coherent content)?

RQ2*: Is there a real advantage in connecting these devices in order to generate additional web content information to a video?*

RQ3*: What are the preferred interface designs for the relevant cognitive modes and needs in each scenario? Along the several options and functionalities, which interfaces work best to support the different cognitive modes (experiential and reflective) and levels of attention?*

RQ4*: What other functionalities would viewers like to have in this kind of crossmedia environment, capable to generate extra web content to video?*

RQ5*: Are the different devices (with different characteristics and thus different possibilities) as part of an ecosystem (in order to have an identical model and functionalities available across devices) easily adopted by viewers?*

RQ6*: Were the proposed frameworks, for crossmedia and iTV, adequate and efficient?*

1.2. Thesis Contributions

The work that has been developed within the scope of this PhD thesis has provided contributions on conceptual, methodological and technological aspects:

- A conceptual framework for the analysis, design, prototyping and evaluation of crossmedia interactive contents based on video, with a strong focus on the conceptual dimensions that should be addressed;
- A conceptual framework for the analysis, design, prototyping and evaluation of iTV contents;
- eiTV application to explore, research and demonstrate the video-based crossmedia concept and design;
- Publications.

A brief section about the eiTV application evolution is presented next, contextualizing the publications that allowed to share and discuss our contributions with the research community.

1.2.1. eiTV Application

Several high fidelity prototypes were designed and evaluated. The development of these prototypes, in conceptual terms, went through three different generations, from simpler interfaces, and functionalities in a linear model to more elaborated interfaces, extended functionalities, a menu based model and a true ecosystem of devices. The generations are characterized as follows:

eiTV First Generation Concept: The conceptual goal was to explore the design of an application capable to generate, from iTV, personalized web contents as additional information to the program being watched, in response to informal learning opportunities, to be seen through PC, TV or mobile phone. The main concern was to explore the model and functionalities that better supported: viewers changes in cognition modes (also implying contributions to the application flexibility and personalization), continuity across devices, contextualization and User Experience (UX) taking the best on each device being used.

eiTV Second Generation Concept: the conceptual shift was based on a ‘beyond iTV’ desire as well as with the appropriateness of a portal instead of an isolated application. Thus, we may say that this generation is more aligned with the concept of 'going beyond iTV in the ***CLOUD'***. The paradigm changed due to technological and social factors. Video can be watched anytime, anywhere, from different types of devices. Each device (TV, PC and mobile phone) may be used to watch the video, create the associated web content and access it. This allowed a natural evolution to a more broad video-based application and an evolution to a Portal with more refined functionalities, a relevant evolution considering that viewers no longer want to be passive. They want a more active role, to collaborate, to create. In this context, it is acceptable to say that consumers have turned into active producers, a role that becomes a true possibility inside a portal with these functionalities. The main concern was to improve the previous model and functionalities, in order to better support: viewers changes in cognition modes (also implying contribute to the application flexibility and personalization), continuity across devices, contextualization and User Experience (UX) taking the best on each device used.

eiTV Third Generation Concept: Conceptually, the keyword here is ***MOBILE,*** 'going mobile', and the flexibility inherent of being mobile with the co-existence of different devices and contexts of use. The goal is to take the best advantage from mobile phones, in terms of mobility and specific features, as for instance: use the mobile GPS to access content through its location and contribute to the enrichment of the application with geo-referenced contents. Another goal was to take advantage from their synchronization with other devices (complementarity), that is to say, simultaneously show different but related information on different devices. This is usually referred to as the 'second screen' phenomenon. As an example, watch the video on the computer while using the mobile device to watch the generated web contents about that video, thus contributing to flexibility, personalization, and adaptation to different cognitive modes. As in the other generations, the main concern was to improve the previous model and functionalities, in order to better support: viewers changes in cognition modes, continuity across devices, contextualization and User Experience (UX) taking the best on each device used with a particular focus on mobile devices.

For each generation, prototypes were designed and developed in order to illustrate and test the proposed application functionalities and design options.

1.2.2. Publications

With the goal to validate and publicize the various concepts, ideas, contributions and results of the work presented in this thesis, to the Scientific Community, several papers and book chapters were published. They are presented next and, for a better contextualization, they are organized by Context followed by each one of the three identified generations.

1.2.2.1. Context

- Prata, A. (2005). iTV Guidelines - A New and Critical Research Area. In Margherita Pagani (Ed), *Encyclopedia of Multimedia Technology and Networking* (pp. 512-518). Idea Group Inc., USA, (ISBN: 1-59140-561-0), April 2005.

  http://www.amazon.com/Encyclopedia-Multimedia-Technology-Networking-Margherita/dp/1605660140

  Contribution: This is a book chapter that presents a detailed list of iTV content design guidelines. Considering that iTV was a recent area, the majority of the guidelines in use were from the web design field and some were directly applied. Thus, a study was conducted in order to: test the few existent specific iTV guidelines and rethink and adapt web design guidelines, in order to propose new guidelines specific for iTV design. The final list of guidelines, along with more recent ones, was used in the development of this thesis prototypes.

- Prata, A. (2008). Interactive Television Research Opportunities. In Margherita Pagani (Ed), *Encyclopedia of Multimedia Technology and Networking Second Edition* (pp. 763-768). IGI Global, Information Science Reference, August 2008.

  DOI: 10.4018/978-1-60566-014-1; ISBN: 978-1-60566-014-1

  http://www.igi-global.com/reference/details.asp?ID=811

Contribution: This chapter describes the research opportunities identified in terms of iTV use and content development. As a consequence, this study allowed identifying research opportunities that triggered part of this work.

- Prata, A. (2008). Interactive Television Evolution. In Margherita Pagani (Ed), *Encyclopedia of Multimedia Technology and Networking Second Edition* (pp. 757-762). IGI Global, Information Science Reference, August 2008.
  DOI: 10.4018/978-1-60566-014-1; ISBN: 978-1-60566-014-1
  http://www.igi-global.com/reference/details.asp?ID=8110

  Contribution: This chapter describes the story of TV from its appearance until the birth and use of iTV systems. By describing the several attempts made in terms of iTV and by analyzing what failed and what succeeded, this work helped by allowing us to use the learned lessons.

- Prata, A. (2008). *Metodologia para Planeamento, Desenvolvimento e Avaliação de Sistemas de Informação para T-learning*. Study presented at ESCE (www.esce.ips.pt), 1 July, 2008.

  Contribution: This study, written in Portuguese was presented in the context of a professional test in order to the promotion to professor at ESCE (www.esce.ips.pt). The study discusses a specific model for the planning, development and evaluation of iTV applications specific to learning (T-learning), thus exploring issues related to learning when iTV is involved.

1.2.2.2. First Generation Prototypes

- Prata, A., Guimarães, N., & Kommers, P. (2004). e-iTV Multimedia System: Generator of Online Learning Environments through Interactive Television. In *Proceedings of INTERACÇÃO 2004: 1ª Conferência Nacional em Interacção Pessoa-Máquina* (pp. 244-246). Lisbon, Portugal, 12-14 July 2004.
  Note: As to this paper, a Poster was also presented.

Contribution: This short paper contains basic ideas in terms of the application purposes and architecture. As it was a first essay, no evaluation results were available yet. The paper was presented at the first Portuguese conference on HCI with the main purpose to validate the idea and collect helpful feedback from other researchers from the field.

- Prata, A., Guimarães, N., & Kommers, P. (2004). iTV Enhanced System for Generating Multi-Device Personalized Online Learning Environments. In *Proceedings of AH 2004* (pp. 274-280). Eindhoven, Netherlands, 23 August 2004.

  Contribution: This long paper contains more concrete ideas in terms of the application purposes, architecture and evaluation method. As it was one of the first essays no evaluation results were available yet. The paper was presented at an International conference with the main purpose to validate the idea and collect helpful feedback from other researchers from the field.

- Prata, A., Guimarães, N., Kommers, P., & Chambel, T. (2006). iTV Model – An HCI Based Model for the Planning, Development and Evaluation of iTV Applications. In *Proceedings of SIGMAP 2006, International Conference on Signal Processing and Multimedia Applications* (pp. 351-355). Setúbal, Portugal, 7-10 August 2006.

  Note: As to this paper, a Poster was also presented.

  Contribution: This is a long paper where a model for the planning, development and evaluation of iTV applications is proposed and presented to integrate and complement various sparse approaches. Considering that an iTV application needed to be planned, created and evaluated, and no complete methodology existed, a more complete one was proposed by the authors and presented in this paper.

- Prata, A., Chambel, T., & Guimarães, N. (2007). e-iTV: Cross-Media Personalized Learning Environments via Interactive TV. In the adjunct

Proceedings of EuroITV 2007 – 5th European Interactive TV Conference (pp. 107-113). Amsterdam, Netherlands, 24-25 May 2007. http://www.cwi.nl/events/2007/euroitv2007/

Contribution: This long paper contains a more comprehensive motivation and design rationale and a more detailed description of the first design of the eiTV, which was based in a linear model (first generation). The architecture, functionalities and the design, planning, development and evaluation model are presented in more detail, while the first prototypes were being implemented.

- Prata, A., Chambel, T., & Guimarães, N. (2010). Generation of Crossmedia Dynamic Learning Contexts from iTV. In *Proceedings of Euro iTV 2010 – 8th European Interactive TV Conference ACM Conference* (pp. 91-100). Tampere, Finland, 9-11 June 2010. http://www.euroitv2010.org/

  Contribution: This is a long paper that describes the first generation design and characteristics in more detail, enhanced features and the first prototypes implemented. The first prototypes were based on a documentary about space and on the well-known CSI series, to explore the requirements of different genres. The main concern was to fully address the support to different cognitive modes and viewers needs and preferences, resulting in three different information levels. Both low and high fidelity prototypes were evaluated through an evaluation process that is presented in detail, along with the encouraging results.

- Prata, A., Guimarães, N., & Chambel, T. (2010). Crossmedia Personalized Learning Contexts. In *Proceedings of HT'10 – 21st ACM Conference on Hypertext and Hypermedia* (pp. 305-306). Toronto, Canada, 13-16 June 2010. http://www.ht2010.org/

  Contribution: This short paper describes some variations to the first implemented prototypes in response to the obtained feedback as well as the evaluation process and the achieved results.

- Prata, A., Chambel, T., & Guimarães, N. (2010). Designing iTV Based Crossmedia Personalized Informal Learning Contexts. In *Proceedings of*

Mindtrek 2010 ACM Conference (pp. 187-194). Tampere, Finland, 6-8 October 2010. http://www.mindtrek.org/2010/

Contribution: This is a long paper which focus is on the results obtained from new and different designs and from the CSI series, the preferred TV series amongst a sample of 243 persons, in order to understand particular and important aspects related to this type of TV genre that could influence design choices to support different cognitive modes, contextualization, etc. This prototype comprised many important details and conclusions in terms of personalization, preferred interaction model, contextualization, amongst others.

- Prata, A., Chambel, T., & Guimarães, N. (2012). Personalized Content Access in Interactive TV-Based Cross Media Environments. In Yiannis Kompatsiaris, Bernard Merialdo, & Shiguo Lian (Eds.), *TV Content Analysis Techniques and Applications* (pp. 331-368). CRC-PRESS, Taylor & Francis Group, March 2012. ISBN: 978-1-43985-560-7 http://www.crcpress.com/product/isbn/9781439855607;jsessionid=a4luPP5knC7A-jRg5m3f1g**

Contribution: This is a book chapter that discusses all the important aspects from the first generation: conceptual framework, linear model, low and high fidelity prototypes (from all versions) and evaluation results. This generation main concern was to explore the model and functionalities that better supported: viewers changes in cognition modes (also implying contributions to the application flexibility and personalization), continuity across devices, contextualization and User Experience (UX) taking the best on each device used (the departing device was iTV).

1.2.2.3. Second Generation

- Prata, A., & Chambel, T. (2011). Going Beyond iTV: Designing Flexible Video-Based Crossmedia Interactive Services as Informal Learning Contexts. In *Proceedings of Euro iTV 2011 – 9th European Interactive TV Conference ACM Conference* (pp. 65-74). Lisbon, Portugal, 29 June - 1 July, 2011. http://www.euroitv2011.org/

Note: This paper was considered one of the conference best papers and thus invited to be extended and submitted to the Elsevier Entertainment Computing Journal.

Contribution: This is a long paper that discusses, for the first time, the second generation architecture (portal) with special emphasis on the design and functionalities associated with this new model. The first evaluation results are presented.

- Prata, A., & Chambel, T. (2013). The Design of Flexible Video-Based Crossmedia Informal Learning Contexts Beyond iTV, to be published soon in the Elsevier Entertainment Computing Journal.

  Contribution: This is a Journal paper that extends the Euro iTV' 2012 paper and discusses, in detail, the second generation architecture (portal) with particular emphasis on the design and functionalities associated with this new model and on the final evaluation results.

1.2.2.4. Third Generation

- Prata, A., & Chambel, T. (2011). Mobility in a Personalized and Flexible Video Based Transmedia Environment. In *Proceedings of UBICOMM 2011 – The Fifth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technology* (pp. 314-320). Lisbon, Portugal, 20-25 November, 2011. http://www.iaria.org/conferences2011/UBICOMM11.html
  Note: This paper was considered one of the conference best papers and thus invited to be published on a journal (work in progress).

  Contribution: This is a full paper that discusses, for the first time, the third generation architecture (Mobile). The first low fidelity prototypes including particular mobile devices functionalities are explained and the evaluation results presented.

- The evaluation results from the third generation high fidelity prototypes are presented, for the first time, in this thesis. However, there is a work in progress in order to publish them soon.

1.3. Research Context

This thesis was developed in the context of the DI: Informatics Department, of the FCUL: Faculty of Sciences from the Lisbon University and in the HCIM group: Human-Computer Interaction and Multimedia Research group, at LASIGE: Laboratório de Sistemas Informáticos de Grande Escala. It was also developed in the context of the “ImTV - On-Demand Immersive-TV for Communities of Media Producers and Consumers" project that tackles different aspects of involving viewers with TV contents in more active ways:

The ImTV project is a project in the context of the cooperation UT Austin|Portugal. It addresses On-Demand Immersive-TV for Communities of Media Producers and Consumers, with the main goals of: studying viewers’ knowledge about key aspects of the new media workflow driving the entertainment industry; understanding and supporting the production side of the new media workflow, exploring the role of intelligent metadata and new digital formats in the production of video programs; developing richer immersive environments and novel feedback mechanisms inferred from richer interactions with media and among viewers; and improving viewers’ experience by offering them a personalized combination of the mainstream TV content together with online user generated content (Magalhães, 2010). This project, which runs from 2010-2013, under the reference UTAEst/MAI/0010/2009, has the participation of the following partners: research teams from FCT/UNL, Inesc Porto, FCUL/LaSIGE/HCIM, UTAustin/USA (University of Austin, Texas); RTP (Portuguese Television Channel), Zon (Portuguese cable TV supplier); FCCN (Foundation for National Scientific Computing), Duvideo and MOG (Media Producers). More information about the ImTV project can be found at Magalhães *et al.* (2012).

The bulk of the work presented in this thesis has been conducted with the support of the PhD scholarship (reference SFRH/PROTEC/67727/2010) funded by Portugal’s National Science Foundation (FCT).

1.4. Thesis Structure

This thesis is organized as follows:

Chapter 1 introduces this work and describes the motivation behind it, defines its objectives and approach, presents the research context where the work has been developed and, in brief, presents the thesis contribution in: conceptual, methodological and technological terms.

Chapter 2 characterizes the state of the art. It reviews main aspects concerning Media, Devices and Internet, where a particular emphasis was given to TV, PC, mobile devices and Internet evolution, properties, trends, uses and adoption. It also discusses crossmedia definitions, types, advantages and challenges. The chapter ends with the discussion of related work in terms of video-based systems, crossmedia systems and video-based crossmedia systems.

Chapter 3 describes the conceptual framework proposed for the analysis, design, prototyping and evaluation of video-based crossmedia applications, as well as the framework proposed for the analysis, design, prototyping and evaluation of iTV services and interfaces.

Chapter 4 presents eiTV, a specific application designed in order to explore, refine and validate our research and the conceptual frameworks proposed in chapter 3. Each one of the three generations is explained in conceptual terms, design, functionalities, evaluation method and results. The results of each generation are also discussed.

Chapter 5 summarizes our main contributions, draws some conclusions, and discusses perspectives for future work.

"To know the road ahead, ask those coming back."
Chinese proverb

2. State of the Art

This chapter provides the context of the thesis by describing the main concepts, developments and related work that characterize the state of the art. It introduces the main concepts behind Media, Devices, Internet and Crossmedia, highlighting their characteristics, evolution and trends, convergence of devices and statistical data related to their use and adoption. Also highlighted are crossmedia definitions, types, advantages, challenges and the existing approaches and tools to support crossmedia design, enumerating the problems that are still present and that need to be addressed. The chapter concludes by detailing the most relevant work within related areas of video-based systems, crossmedia systems and video-based crossmedia systems.

2.1. Media, Devices and Internet

In a video-based crossmedia context, the more used devices are iTV, PC and mobile devices (especially mobile phones and in particular smartphones) as supported by statistical reports (Lima, 2011; Turril & Carter, 2012) and by a literature review on crossmedia systems (Aroyo, 2012; Guérin, 2010; Jenkins, 2011; Martin *et al*., 2010; Strover *&* Moner, 2012). This section presents the characteristics, evolution, trends, adoption and usage pattern of TV, PC, mobile devices, Internet and the convergence of these devices and technologies.

2.1.1. Characteristics, Evolution and Trends

Several factors contribute to the evolution of interactive devices, from which the more significant are peoples' aptitude to use them and technological advances. Users propel industry, but the contrary is also true considering that the availability of devices with attractive functionalities are also capable to create on users the will to try them out. Thus, and independently on which propels which, what is a fact is that industry does not stop trying improving and diversifying its offer. Constantly, new products are arriving to the market. As a consequence, the characterization of each device is difficult considering the exponential speed of evolution in terms of technological characteristics and paradigms of use. As to other types of characteristics, as for instance, of use, we are also witnessing a change of paradigm. Main TV, PC, mobile devices and Internet characteristics, evolution and trends are presented in more detail in the next sub sections.

2.1.1.1. TV

Television was a brilliant invention since it is capable of transporting us anywhere (Perera, 2002). Since its first production, in 1928, it never stopped spreading and by now the TV penetration rate rounds 99,9% (Paisana & Lima, 2012) which means that almost every home has, at least, one TV set. However, the TV paradigm which has traditionally occupied the largest share of consumer leisure time has been changing. In fact, and with a start in the so-called “digital revolution”, TV has been undergoing a process of technological evolution. The traditional TV sets and programs (which are typically watched in more passive ways when not supplied with a set-top-box) are being replaced by digital TV sets, which allow a long list of new interactive services and programs as interactive television (iTV). There is no doubt that iTV, which can be defined as a TV system that allows the viewer to interact with an application that is simultaneously delivered, via a digital network, in addition with the traditional TV signal (Perera, 2002) has been replacing the traditional TV viewing habits. In fact, in the past, television has generally been used as a ‘sit back’ medium, in a ‘lean back’ attitude, when referring to the viewer passivity towards TV. Now, through interactivity, and the range of programming choices offered by digital television, the viewer easily adopts a ‘lean forward’ attitude, actively engaging in programming content and interactive applications (Bonnici, 2003; Cesar & Chorianopoulos, 2009; Gersmann, 2012; Krautsieder & Wörmann, 2012).

The history of iTV is full of pitfalls which have dictated a journey of advancements and recoils (Abreu, 2007; Prata, 2008b). Nevertheless, iTV technology combines the appeal and mass audience of full motion TV with the interactivity of the web and the internet, providing new services, giving viewers more control over what they see and creating a new and very rich environment. It has been, in the opinion of many researchers and producers, a technology increasingly being used and that is believed to conquer its market space (Abreu, 2007; Cesar & Chorianopoulos, 2009; Gerstmann, 2012; Prata, 2008a; Quico, 2004). This conviction is clearly supported by the number of research studies that were conducted on these last years, especially the last decade. Some studies have identified a potential for the use of iTV for increasing learning opportunities in the home, in particular through personalized options and as an alternative solution to utilizing an Internet-enabled computer (Bates, 2003) and the need to find ways of utilizing the powerful combination of broadcast TV and interactive services to provide hooks to draw viewers into active learning environments (Bates, 2003). This is possible if through consistent learning services development, that should consider jointly: technology solutions, the development of sustainable models and pedagogical issues (Prata, 2008a). This learning environment made available through TV, and known as T-learning, main advantage is: to provide the viewer with learning from home and through well-known equipment (Bates, 2003). There are important reasons to opt for this solution: almost every home has at least a TV set, not everybody is interested in having a PC internet connection or is interested in e-learning systems, TV is very easy to use when compared to PC or mobile devices, requiring less technological literacy [2], people tend to trust on contents delivered through TV, TVs are able to reach almost everyone and present an unlimited number of learning options (contrary to a specific learning institution). A list with several examples of T-learning is presented at http://www.pjb.co.uk/t-learning/casestudies.htm.

In an article published in the Forbes magazine, Ostrow (2010) stated that “television is about to become the latest medium to get a major makeover at the hands of the Internet”. His comment was based mainly on two factors: more than 50% of Americans are used to watching TV and surfing the web

[2] Technology literacy is the ability of an individual, working independently and with others, to responsibly, appropriately and effectively use technology tools to access, manage, integrate, evaluate, create and communicate information. (Montgomery School, n.d.)

simultaneously; and the changing paradigm associated to the increasing capabilities, in terms of connectivity and interactivity, that has being given to TV.

Following these changes of paradigm, another strong tendency arises, with the adoption of the so called ‘second screen’ modality of use, which means to use a ‘second screen’ (besides the TV) in order to act as some sort of ‘companion device’ or ‘companion app’ (when referring to software). The second screen is a concept that arose due to the viewers’ tendency to use other devices simultaneously with TV and refers to an additional electronic device (e.g. PC, tablet, smartphone) that allows a television audience to interact with the content they are consuming, such as TV shows, movies, music, or video games. Extra data is displayed on a portable device, synchronized with the content being viewed on television (Biggs, 2012; Carey, 2012; Fleury et al., 2012; Vanattenhoven & Geerts, 2012).Thus, this concept always implies the use of the TV as main source of information and the simultaneous use of other devices in order to allow viewers interaction with the TV content. This interaction may vary from the most basic, as sending a sms to participate in the TV program, to more elaborated systems, as having extra data displayed on a portable device synchronized with the content being viewed on television. Many applications in the ‘second screen’ are designed to give users another way of interactivity and to give advertisers another way to sell advertising content (Good, 2011; Fleury et al., 2012). As an example, the transmission of the Master's Golf Tournament, application for the iPhone. The TV is used to watch the games, and the iPhone or iPod to see the rating information and publicity[3] as a crossmedia application. Nevertheless, a Second screen service is always crossmedia but the contrary is not true. In fact, there are crossmedia systems that rely solely in PC and mobile phones.

Concluding, the changes in paradigm when referring to the use of the device also conducted to an adaptation of language. As stated by Strover *&* Moner, (2012), during the past decade, the concept of television shifted in order to “include any screen or device that delivers television programming”. As a consequence, television industry is adapting its language, namely, evolving

[3] https://itunes.apple.com/us/app/the-masters-golf-tournament/id309025938?mt=8

from ‘television programming’ to ‘content’. This change demonstrates that “television producers and industry recognize the multi-modal delivery systems available to audiences and fragment their viewing experiences across multiple devices and multiple modes of viewing.” (Strover & Moner, 2012)

2.1.1.2. PC

Personal Computer (PC) was a term used for the first time in November 3, 1962, in a New York Times article (Mauchly, 1962). From there to the first bulky desktop PC announced by IBM in 1981, and until nowadays it evolved dramatically.

In general terms, over the years, technology miniaturization allowed for smaller PCs. Now they are very small when compared to the first desktop PCs. This miniaturization process was accomplished due to the constant technological improvement which main goal was to achieve smaller computers with improved capabilities: more memory; faster processors; inclusion of hard disks; improvement of backup devices (from floppy disks to CDs, DVDs, USB, etc); migration to the laptop – the ones that may be hold on laps – much in use today. Laptops were possible due to the flat screen LCD technology, replacing those based on cathode ray tube. By attaching the flat screen to the keyboard, we have a more portable and smaller computer and by including a lithium battery, mobility became a reality; other improvements were the inclusion of sound columns and video cameras; mouse; touchpad; wireless technology; Wi-Fi; etc. As Bezi (2010) argues, laptops are not really mobile considering that they need power connection, since the battery lifetime is short (a few hours). In fact, the battery is not enough to allow an entire day of use without the need to be reloaded. He also states that laptops are heavy (more than 2,3 Kg) and big in size not making it easy to carry. This is why technology never stops trying to improve, and after the boom of laptops it is now time for a new generation of buzzwords as netbook, ultra book, and others, towards lighter and more autonomous devices.

PCs, by nature, induce a ‘lean-forward’ attitude. Using a PC usually implied interactivity, independently on the viewer activity being work or leisure. In fact, the attitude was rarely just standing in front of a PC but, instead, interacting. First through specific work and games software and later, with the appearance of the internet, through online games, information search, participation in blogs, use of social network, messenger, chats, and many other interactive applications and tools. This level of interactivity obviously required specific hardware in order to facilitate navigation as the keyboard, mouse, touch pad, etc. This was one of the first devices used to access internet services and, for years, the most common. Thus being, for many it still is the preferred option when to access internet services, search and web contents navigation.

Only in the last decade, due to technological advances, the use of video with quality became possible: through DVD recorded films, from internet services using video streaming like youtube, and more recently through mobile TV. However, in spite of being able to present us with video in several forms, the truth is that when reaching the video requires some interactivity, as for instance youtube videos, viewers' first option is the PC. To watch films the first option remains the TV (Guérin, 2010).

2.1.1.3. Mobile Devices

In the early nineties, GSM (Global System for Mobile Communications), the second generation mobile technology able to carry data and voice traffic was developed. It was in 1992 that the first GSM phone, the Nokia 1011 was launched (Bezi, 2010). Mobile devices are also commonly known as handheld devices, handheld computers or simply handheld. Following Hanson (2011), the more recent mobile devices are characterized by being small, a hand-held computing device, typically having a display screen with touch input and/or a miniature keyboard and weight less than 0.91 kg. They also have an operating system (the smartphones) and are capable to run several types of application software, usually known as apps. Most hand held devices can also be equipped with WI-FI, Bluetooth and GPS capabilities that can allow connections to the Internet and other Bluetooth capable devices. A camera or media player feature for video or music files can also be typically found on these devices along with a stable battery power source, such as a lithium battery that may last for days without the need for recharging. That lithium battery as well as the small size is exactly what is in the basis of their mobility.

The PDAs and Smartphones popularity relies on the fact that they present us with some of the power of a conventional computer when using one is not practical, as for instance on the move (LTR, 2008). However, PDAs are no longer a hit and since around 2010 the new fashion device, similar but larger, is the tablet computer (Hanson, 2011).

As to mobile phones and smartphones, they are considered an integral part of peoples' daily lives. From all the available computing devices, they are the more personal and powerful considering that they are a "computer in a pocket" (Casey & Turnbull, 2011; Kaasinen, 2005). In fact, in spite of being compact, these devices may contain many types of personal data and be used in many different ways. They may be used to communicate (through gsm voice calls, on the internet, via web social networks, blogs, chats, etc), to send and receive pictures, record and use audio and video, take notes, use tools as the GPS and many other tasks. In sum, it is becoming possible to use these handheld devices in more similar way than we have used laptops during the past decade (Casey & Turnbull, 2011). As stated by Keinänen (2011), during the last few years, with the rush of touch screen mobile devices on the market, mobile web browsing has increased more than 100% per year.

These devices are so powerful that they have completely changed our lives. As stated by Chen (2011a) Apple, through the launch of iPhone (in 2007) and the app store, was able to unlock what they decided to call the "anything-anytime-anywhere future". In fact, the iPhone was really the first complete integration between a mobile phone and a PC platform that was internet and multimedia enabled (Bezi, 2010). Nowadays, there are other devices capable to do the same. The main question is on how these technologies are capable to change people's lifes. If we have access to data everywhere, all activities that we are involved in can be arranged in accordance: learning, teaching, fighting crime, report news, etc. As an example, Chen (2011b) presented the case of a victim of the Haiti earthquake which save himself by using an iPhone medical App in order to help him treat his wounds.

Concluding, from a technical point of view, mobiles and smartphones are capable to provide access to the same internet services as a PC. However due to a smaller screen size, and although current browsers already addressed this limitation, the mobile browsing experience is still far from being truly enjoyable (Roto, 2006) especially when compared to the PC browsing experience. Mobile devices provide viewers with the unique possibility of being always connected, always reachable on the move, and they are adequate to provide users with specific and useful apps and functionalities. Thus, mobility and specific functionalities, as for instance: phone calls, sms, MMS and GPS are they main strengths. But when the intention is to access the internet the truth is that, if at home, the tendency still is to use PC instead the smartphone. This tendency will probably change in the presence of tablets considering the good screen size, low weight and portability.

2.1.1.4. Internet

Internet is a short form of the technical term internetwork and is a global system of interconnected computer networks to serve billions of users worldwide. It is a *network of networks* that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies (Gralla, 2006; Levine & Young, 2011). Every time we use the Internet, our own computer becomes an extension of that network (Blum, 2012). As any other technology, it also evolved dramatically since its origins in 1960s when the United States Government were trying to build robust, fault-tolerant, and distributed computer networks. In the 1980s, public and private fundings led to worldwide participation in the development of new networking technologies, and the merge of many networks. Finally, in the 1990s it started spreading and due to its popularization, it was incorporated into virtually every aspect of modern human life (Ryan, 2010).

The majority of traditional communications media as telephone, music, films, and television are being reshaped or redefined by the Internet, giving birth to new services such as Voice over Internet Protocol (VoIP) and Internet Protocol Television (IPTV). Newspapers, books and other print publishing are adapting to World Wide Web (WWW), or Web, site technology, or are reshaped into blogging and web feeds. It is important to say that this adaptation is crucial to the survival of these communication media considering that the Internet has definitely changed the way in which people interact with them (Paisana & Lima, 2012).

The Internet has enabled and accelerated new forms of human interactions through instant messaging, Internet forums, and social networking which allow us to communicate with others independently on the geographical distance. It also carries an extensive range of information resources and services, such as the inter-linked hypertext documents of the Web and the infrastructure to support email (Blum, 2012). From a computer, we can find information about everything that we can imagine, exchange every type of files, set up a teleconference, videoconference, visit the best museums in the world, shop online, watch videos, listen to music, read magazines, etc (Gralla, 2006).

Thanks to some technology trends, television channels are not the only ones to be able to offer video entertainment anymore. Following Guérin (2010), the use of TV on the web is a growing tendency. In fact, several recent technology trends, as advances in video compression and the growth in network IP capacity, have combined to allow delivering high-quality video content over the internet, the same as over IP networks, to an enormous number of viewers, feasible from a technically and economically perspective (Simpson, 2008). However, different applications, standards and technologies are available for delivering video through IP, as for instance, Streaming and the Internet Protocol Television (IPTV).

Streaming is a technology based on a specific delivery method. What happens is that a user may start playing a video, or any other content, before the entire file has been transmitted, meaning that the video is being watched while being delivered by the provider (Simpson, 2008). The video is delivered over a network in a continuous flow “at a rate that matches the speed at which data is consumed by the display device” (Simpson, 2008). Considering the size of a high-quality video, this technology is very useful in order to allow viewers to watch the video without having to wait for the complete transmission.

IPTV is a way of delivering traditional broadcast channels to viewers over an IP network. It is true that it uses IP network but not exactly the public internet. In fact, “IPTV services are almost exclusively delivered over private IP networks” (Simpson, 2008).

2.1.1.5. Convergence

Technology evolved in a direction that leads us to the sophistication of TVs, PCs and mobile devices. In fact, higher bandwidth, better resolution, sophisticated interfaces means that watching television on the PC is becoming more close to traditional TV. On the other hand, digital TVs aggregate more and more interactive possibilities and they are easily connectable to networks like the internet, thus becoming more like PCs (Cardoso *et al*., 2011; Krautsieder & Wörmann, 2012). What this really means is that the differences between TVs and PCs are becoming blurred over time, allowing a TV content shifting to the Web as delivery platform – “an explosion in available content at anytime” - and a web content shifting to the TV in order to augment the TV experience which may be considered as an “explosion in additional content at anytime” (NoTube, 2012).

Other tendencies are emerging due to the miniaturization of devices and the mobility appeal. Now, it is possible to access television contents for e.g. while in a bus queue, through a mobile phone. We are witnessing a screens explosion: from the traditional TV, to PC and mobile phones screens. The same consumer may assist the same content sequentially or in an alternate fashion and choose the most adequate device to each context of use (Dearman & Pierce, 2008).

Based on these new trends, nowadays, TV means different screens with similar contents. By the end of 2010, television programs no longer require a TV set and videos do not require video hardware for viewing. A movie or video may now be watched on a TV screen, a PC, a mobile device, a tablet, or a gaming console (Krautsieder & Wörmann, 2012; Strover *&* Moner, 2012), meaning that what was once studied as a home activity has now become an activity that may occur everywhere through completely different devices. Also important to refer that devices may be used in order to present the similar content when used individually, or to present complementary content when used in a synchronized fashion, being an example of this last the so called ‘second screen’. TV, more than a support platform, may now be defined as a system of experiences where three main evolutionary processes articulate: technological evolution, creation of contents and creation of new uses. For now, a new paradigm is being born: the network TV. Some may argue that the TV image and sound quality remains yet much higher than online, but the tendency is to the convergence of quality. On the other hand, sometimes, consumers prefer this trade-off between quality and accessibility (the well-known ‘good enough theory’) (Cardoso *et al*., 2011).

As to the viewers attitude towards interaction, a study conducted by Strover *&* Moner (2012) in the context of the ImTV project, with young students ranging from 18 to 22 years old, showed that viewers are becoming more active and that creating and sharing contents are practically a daily activity, being Facebook the dominant medium (87,6%) followed by YouTube (57,9%). The results suggest that the audience is changing and that now they expect to create and use content in various forms and places. In fact, they spend two to three hours a day using technology in a “lean forward fashion”, rather than in a “lean back” fashion. The study also revealed that a typical student's media environment now includes entertainment offerings inclusive of YouTube videos, Facebook interaction, share pictures, personal videos, content libraries available on Netflix and Amazon, Twitter feeds, instant messaging, chat, and many others.

Concluding, the main tendencies in what relates to TV viewing are the audiences and media fragmentation, consumption personalization, increased mobility, interactivity and network articulation.

In spite of the aforementioned change of paradigm, TV remains the strongest device in what relates to video watching, the same way that PC remains the strongest device in what relates to accessing web contents. TV is part of the general population daily routine, especially of the oldest ones. However, new consumption patterns capable to coexist with the traditional viewing mode are emerging, especially on younger populations (Cardoso *et al*., 2011). New and different products need to be produced in order to accommodate this change of paradigm, especially in what relates to the use of network TV or video. To have products adequate to accommodate youngest viewers needs across devices is essential, and to create products and conditions to attract the oldest ones is also needed. The developed products and solutions will have to be, somehow, technology independent, considering that what is now impossible from a TV device may be only a few days away from being possible (Chen, 2011b). It is exactly at this point that our work contributes, considering that we are in fact exploring the design of video-based crossmedia contexts and proposing a solution for devices like TV, PC and mobile devices (smartphones). Our solution was designed in order to accommodate younger viewers (our target population) needs across devices, but is also prepared to oldest people and those with lower technological literacy by having different levels of interactivity. Technological literacy "is the ability of an individual, working independently and with others, to responsibly, appropriately and effectively use technology tools to access, manage, integrate, evaluate, create and communicate information" (Montgomery School, n.d.), or in brief, may be interpreted as the amount of theoretical and experimental knowledge on technological issues.

2.1.2. Adoption and Use Patterns

In section 2.1.1., it was mentioned, in global terms, that TV, PC and mobile devices are the most used devices. However, and considering that there are specific entities responsible for regularly gathering this type of information, we present more detailed information about the attitudes and patterns of use and adoption for each device and for the Internet.

2.1.2.1. TV

In Portugal: The adoption of television is almost extensible to the entire population (99,9%) from 15 to 74 years old (Paisana & Lima, 2012). From a specific study, around 30% of the respondents are using TV more than they used five years ago. In fact, TV is in a more comfortable position than the other traditional media (radio, newspapers, etc). However, between those who are using more TV nowadays, oldest people and lower level literacy are the two categories more represented (Cardoso *et al*., 2012; Lima, 2011).

Cable TV augmented from 37,7% in 2008 to 42,8% in 2010 and a considerable number of respondents (42,8%) do not classify the use of digital television as complicated (Lima, 2011).

The level of trust associated to the information available from TV is higher when compared to the other Media. In fact, the big majority of respondents consider that TV is the most important and efficient platform in order to obtain information about national or international, actual or past events and news

(Lima, 2011). To the majority of the respondents, the activity of watching TV is understood as the most difficult to stop doing (44,2%), followed by the use of the mobile phone (26,6%) and the use of Internet (14,2%) (Lima, 2011).

The study conducted by Strover *&* Moner (2012) in the context of the ImTV project, states that young Portuguese students population view media on their laptop devices, but 75% also opts for television as a secondary display device in order to watch cable television material (78%). It was possible to perceive that the "old" medium of the television screen is still popular, although more in Portugal than in the U.S.

In the USA: In average, Americans watch nearly 5 hours of video each day. From these, 98% are watched on traditional TV (Turril & Carter, 2012). However, the paradigm is changing and we are witnessing a viewers' change of habits: the viewers 'hunt' for the best screen available, which means the more adequate to each context of use, and the use of more than one device at the same time. As to the best screen available, the order of selection is: TV, Internet (PC), mobile phones and game consoles. As to the use of more than one device simultaneously, a study revealed that more than 50% of Americans are used to watching TV and surf the web simultaneously (Ostrow, 2010). On the first quarter of 2011, and in what relates to the simultaneous use of TV and Tablet: 45% at least do it once a day; 69% do it several times a week; and only 12% have never done it (Turril & Carter, 2012). The study conducted by Strover *&* Moner (2012) states that young American students view media on their laptop devices, but 47% also opt for television as a secondary display device in order to watch cable television material (63,5%).

Another important discovery was that traditional television channels have seen their audience numbers dramatically reduce (-15 to -30% depending on the channels) during the past decade. However, contrary to what this may seem at first sight, it is not the end of television, on the contrary. Traditional channels have lost audience due to the advent of Digital Television with lots of channels. Meaning that what happened was just a simple audience spread out (Guérin, 2010).

It is important to refer that the popular belief that Internet was going to turn spectators away from TV, is not true like TV did not kill radio or newspapers, they just co-exist in different forms. Things are changing, the viewing paradigm is changing and now, besides being more spread out, the audience is also multitasking, especially the young audience. Strover & Moner (2012) states that young people, especially those in colleges whit high speed Internet connections, watch television programming differently than previous generations of viewers who were just seated in front of a TV set. She refers that these young adults viewing habits “could be characterized as anything but stable”. In fact, they use various devices to view television, and they “often respond to the content through exchanges with friends and by remaking spinoffs of it, viewing in waves as some things ‘go viral’ on YouTube and routinely following ‘TV’ via online services” (Strover & Moner, 2012).

2.1.2.2. PC

In Portugal: Half of the entire adult Portuguese population (50,5%) has a laptop, while the rate of adults with desktops is 35,2% (Paisana & Lima, 2012).

In Europe: As to Households with a computer in Europe, and considering the information from the ITU report (ITU, 2012a), 75,3% have computers.

In the USA: Considering the entire US population and from quarter 3 of 2008 to quarter 3 of 2011: watching video on the internet through PC augmented 21,7% in users and 79,5% in time spent among users (Nielsen Company, 2012).

In the recent study conducted by Strover & Moner (2012) with a Portuguese and American student population ranging from 18-22 years old, 71% of the overall sample indicated to use a laptop frequently or very frequently as the primary medium for watching entertainment. On the other hand, a very low percentage uses desktops or tablets for watching entertainment - US: 11% and Portuguese: 12% - and Portuguese students reported preferring mobile phones for entertainment. In what relates the use of laptop computers to download or stream video, the percentages are very high: 33,9% weekly and 32,3% daily use. Laptop computers were used extensively for viewing films, television and entertainment content, especially amongst U.S. students from which 75% reported frequent or very frequent against 68% of the Portuguese sample. Laptop computers are a heavily used second screen, and cell phones appear to be the third screen.

2.1.2.3. Mobile Devices

In Portugal: The number of mobile phones subscribers in 2011 was 12.284.594 (meaning 114,92 subscriptions per 100 habitants) (ITU, 2012b). It was in 2010 that the number of subscribers surpassed the 100% (Cardoso *et al*., 2012).

From his inquiry, Lima (2011) concluded that 47,8% of the respondents use the mobile phone more than they did 5 years ago. Another study (*Cardoso et al*., 2012) revealed that, in 2010, the respondents used the mobile phone to the following tasks: to phone calls 92,5% (decreased); to send and receive sms 66,9% (increased); to take pictures 40,9% (increased); to send and receive mms 25,1% (increased); send and receive e-mail 5,4% (increased); use the GPS (4,4,%) and watch TV (4,1%). The most interactive tasks are mainly attributed to younger populations and the tendency suggests that low levels of literacy are associated with low level of mobile phones and internet use. 47,8% of the respondents said that they use more the mobile phone than they used five years ago (Cardoso *et al*., 2012).

In Europe: The number of mobile phones subscriptions in 2011 was 747 million; 120,8% (ITU, 2012a). As to the UK population in 2011, 44% used smartphones (more 4% than in 2010) (OFCOM, 2012).

In the US: In terms of mobile users, 40% own smartphones and from those, 40% are Android (Kellogg, 2011). As to the entire US population: From quarter 3 of 2008 to quarter 3 of 2011: watching video on a mobile phone increased 205,7% in users and increased 19,8% in time spent among users (Nielsen Company, 2012).

In the World: There are about 7 billion people in the world and acording to Laughlin (2012) in the first three months of 2012, there were 6.2 billion subscriptions. According to a report by telecoms giant Ericsson released on June 5 from 2012, by 2017: there will be 9 billion mobile subscriptions while the population is expected to reach 7.4 billion; 85% of the world's population will have 3G coverage, as a result, there will be 15 times more mobile data traffic; half of us will be able to access superfast 4G mobile data and the number of mobile handsets with internet connection is expected to grow to around 3 billion, up from just 700 million at the end of 2011.

By the end of 2010, one in three devices was a smartphone, a MID (Mobile Internet Device), or a Netbook (Bezi, 2010). Current mobile internet usage and video watching was found to be considerably higher among owners of Apple iPhone, followed by users of devices running Google Android and Windows Phone (Laughlin, 2012).

According to a Nokia slogan, life goes mobile! However, while on the move, people use services that provide utility, communication, or fun. In fact, some web contents are more useful on the move than 'at the desk' and to watch the news or funny videos are certainly an interesting way to pass time while waiting in a bus queue. As a result from the study conducted by Strover *&* Moner (2012), mobile phones are used for viewing films, television and entertainment content (11,2% U.S. and 12,2% Portuguese). For now, mobile phone occupies a discrete position in terms of its role as a content creator and disseminator. However, in the authors' opinion, mobile is going to occupy an increasingly important role in the content connections considering that it offers portable opportunities for the "connected viewing and creating" that typically catches users' attention. Many people are using mobile phones to stay connected to Facebook, a service that was considered very fashionable, engaging and extremely attractive to its users due to its attributes: being free, easy to use, with interesting content, and so forth (Strover *&* Moner, 2012). Thus being, considering that: the technology already arrived; the motivation is already enrooted in viewers and that they already started using technology, it is just a matter of time and user experience until the masses start to engage in a more profound interaction through their mobile phones, using them in order to browse the web, watch TV, videos, etc in a daily basis.

As stated by Guérin (2010), in 2014, mobile devices will have surpassed traditional computers as the prime way of accessing the Internet, thus providing an improved support to access and watch video through better interfaces, with higher sound and image quality and higher speed than we have now. As a consequence, new challenges will arise. As stated by Hans Vestberg, the Ericsson president "with this kind of mobility and connectivity everywhere, there will be no differentiation between a business user and a private user", meaning that networks will need to be built and designed in order to accommodate not only the traffic growth but also the complexities in the different devices and kind of traffic that flows across mobile networks (Laughlin, 2012).

2.1.2.4. Internet

In Portugal: In 2011, the percentage of individuals that are Internet users is 55,3%, and this number has been increasing every year (ITU, 2012b), 57,2% with domestic access (Paisana & Lima, 2012) and 58% in the first trimester of 2011: an increase of 4,3% in one year (ANACOM, 2011). In 2010, 31,1% of the respondents to a study said that they use the Internet more than they used 5 years ago (Cardoso *et al*., 2012).

The most used task through internet is sending and receiving e-mails (87,3%). Social networks are the second task of communication more disseminated (73,4%) (Paisana & Lima, 2012).

In Europe: In 2011, the percentage of individuals that are Internet users is 70,9% (ITU, 2012a). As to the UK population, in 2011 the use of the internet anywhere, on any device was 79% (against 59% in 2005) and over time, people are doing more things online, with increases across most types of activity. Half of online users are now carrying out between 11-18 different types of activities (OFCOM, 2012).

In the world: The percentage of individuals using the Internet continues to grow worldwide and by the end of 2011, 2.3 billion people used the services of the Internet (nearly a third of earth's human population). By the end of 2011, 70% of the total households in developed countries had Internet, and only 20% in developing countries (ITU, 2012c). In Strover *&* Moner (2012) study, it was found that what constitutes the source of visual material web-based films (such as the ones available from Amazon or Netflix) were the most popular: 78% of American students use these services regularly. Also important to mention that video represented over 50% of global Internet traffic in 2010. According to Cisco, by 2014, video will represent 91% of global traffic (Guérin, 2010).

2.1.2.5. Convergence

The concept of "television," as it was defined by Spigel (2004), needed to change in order to encompass viewing, using and sharing content on multiple screens (Strover *&* Moner, 2012). The media marketplace has witnessed an increase in the amount, types and characteristics of viewing devices available to users. In fact, from the traditional television set, to laptop computers, to tablets, to pocket-sized mobile phones, people now have an enormous number of choices available for entertainment purposes. Besides, many of them are portable, and support enormous personalization opportunities. Technology, distribution, reception and content developments all influence new “television” viewing and using habits (Strover *&* Moner, 2012).

In the study by Strover *&* Moner (2012), participants, students ranging from 18-22 years old, where asked about the simultaneous use of devices when viewing a film or television program: 78% use a mobile phone to send and receive text messages; 76% reported using a laptop computer to communicate about the content they are watching, usually through instant messaging or Facebook (FB). These results do hint that the paradigm of interaction is truly changing and viewers are very engaged in interacting. Students also pointed mobile technologies such as laptop computers, mobile phones (in particular smart phones with Internet connection), and tablet computers as the devices that allow to engage content in more places and at more times than ever before. In general, tablets computers were not yet being used in great number. Television is still popular, more so in Portugal than in the U.S., laptop computers are a very used second screen, and mobile phones are the third screen. There is a strong evidence of a shift from the usage of television content on standard audiovisual devices such as the television to portable platforms, in particular the laptop computer. Using a laptop computer is nearly as common as using a television for entertainment and one tenth of the sample uses various devices for entertainment in public places rather than the home, a trend more pronounced among the U.S. students.

When asked about what services they use to share their creative work, students’ focused largely on FB (87,6%), YouTube (57,9%) and email (64,9%). As to the US students, the percentage was 95% to FB. It was found that the use of FB is so dominant that the device platform does not appear to matter: people are on FB a lot, wherever they happen to be and whatever technology is in their hands. Everyone uses it, and they use it nearly everywhere as well. FB is the dominant medium for sharing and commenting on others’ content and for sharing one’s own content as well. As a consequence it is the application that mostly propelled the shift to the use of mobile devices to access the web. People are so eager to use it that they are surpassing questions related to user experience. This 'migratory movement' to the web via mobile phone was triggered and is already creating different habits of use that, once acquired, will remain even when using other services.

Guérin (2010) states that "the teenager who watches 'Pop Idol' while sending text messages, surfing on youtube and publishing a Facebook status is a goldmine". It is important to keep in mind that they are early adopters of technology and that today's young audience is tomorrow's mainstream one and it will be fundamental to be prepared to this new paradigm of interactive viewing habits. On the other hand, they are valuable considering that they may set the agenda for how other generations engage with entertainment programming of various sorts. However, for now, even the teenagers' parents (which represent the actual mainstream consumers) may already be considered a goldmine because they are the ones who are already shifting the paradigm. They use Facebook and surf the web while watching TV, they do not go anywhere without their smartphones, which they are able to use in order to capture videos, surf the web, record sounds, use email, take pictures, etc (Guérin, 2010). In sum, and in terms of activities, the ability to quickly upload or download content, the opportunity to sample a range of content, to share work simply and immediately, is what the new culture appears to desire. This is a paradigm shift away from the notion of programmed content channels that implied a 'lean back' attitude. Both generations create and interact in a 'lean forward' fashion, rather than a 'lean back' fashion to just consume. It is important to understand that all these new tools appeared in the last 10 years and that people adopted them beyond all expectations, using them in their day-to-day life. Concluding, if viewers are used to this level of interaction, how can they now be satisfied with only one level of entertainment? There's only one path to follow… the convergence of devices, thus, the use of crossmedia applications - in spite of all the significant challenges for designers, researchers, producers - taking the best of each device involved!

2.1.3. Discussion

There are a lot of changes going on. In general, all devices and Internet connections are improving in technological terms thus becoming much more attractive due to better hardware speed, network bandwidth, increased interfaces usability and functionalities. At the same time, the paradigm of use is changing. Due to several factors, as for instance the proliferation of cable TV, people are becoming used to watch TV interactively (through iTV) or to be interactive while watching TV, by using other devices at the same time. Many studies show a clear tendency to use a device while watching TV, usually, tablets or smartphones (Casey, 2011). Other studies distinguish a higher percentage of comments or posts on social networks, about the content that is being watched (Nielsen ratings) (eMarketer, 2011). As well, Google published a study where they define some apparent new users' behaviors when consuming content via multiple devices (Google, 2012). These studies revealed that many companies, in the area of content production and advertising, have adapted their formats to the user, trying to get maximum attention and thus profits. As a result, applications are becoming a natural extension of television programming, both live and on demand. These applications, used in second screen, are already a tendency. In fact, and as presented in section 2.1.2.5., while watching TV 78% of young students ranging from 18-22 years old are already used to watch TV and another device simultaneously. The paradigm of seating on the couch, lean back and simply watch a whole TV program without engaging in some sort of other technological adventure is becoming rare (Paternò & Santoro, 2012). It is mostly amongst the oldest and the less literate that this occurs more frequently. There is a change in attitude due to life circumstances, there is never time to real stop and settle down. There is also a change in attitude propelled by technology advances (like more interactive applications or the mobility appeal where there are no limits to when and what), and there is a change in technology advances propelled by changes in peoples' attitudes of wanting more and more interactive applications and devices. The trends are going in the direction of integration, of convergence, of crossmedia applications.

In fact, in the past 10 years, technological advances and innovations have revolutionized not only devices and communications but also users' behaviors as well. Digital TV, video sharing websites, social networks, mobile phones and smartphones, high speed internet, so many elements that changed information, communication, entertainment, interaction, sharing and also buying habits. The emergence of crossmedia applications, from which the 'second device' applications are a subcategory, is in order to reach two goals: reach out the audience wherever and whenever (mainly due to the mobility brought by mobile devices), and offering a rich interactive multitasked and personalized experience. New paradigms of use are calling for these environments considering that: by 2017, the number of mobile devices will surpass the number of human beings; in two years, it is expected that mobile devices will surpass the PC in what relates to Internet access; the more active viewers, which are the adolescents, will in a few years become the mainstream audience; TV channels are already integrating crossmedia into their programs and it is expected that within 5 years the audiovisual production will be conceived for plurimedia: a TV series, a film, a documentary, an echo on the Internet or on mobiles. Considering all the evidences, it becomes clear that, both from a technological and sociological perspective, crossmedia is the direction to follow!

2.2. Crossmedia

This section discusses the crossmedia concepts relevant to our work. It presents the motivation for using crossmedia and the different definitions, discusses the advantages and challenges associated to crossmedia, and the existing approaches and tools to support crossmedia design, also identifying the problems that are still present and that need to be addressed.

2.2.1. Motivation

Increasingly, interactive applications are becoming less restricted to a single media technology. In fact, as explained before, the proliferation of new devices able to support human activities across a range of contextual settings (Oulasvirta, 2008), just like it happens in 'real life', is one of the main motivations for media integration. We are therefore witnessing the growth of a new generation of applications which are no longer limited to one single media technology, such as mobile devices, computers or interactive television (iTV) but that include many of them. These applications, named crossmedia, are particularly interesting in what concerns the opportunities they create in terms of communication, entertainment, learning, and other activities (Bates, 2003). In terms of learning support, these applications are particularly promising due to the emerging era of lifelong learning where informal learning will become as important as formal learning (Bates, 2003; OECD, 2004), calling for flexible environments. Considering that these applications are very promising but are recent and many conceptual questions are yet unsolved, they are a good opportunity for research which is also a motivation.

2.2.2. Definition

Crossmedia, cross-media, transmedia, cross-device, cross-platform, multi-platform are sometimes used with the same purpose (Wäljas *et al*., 2010). However there are some differences that should be clarified, starting by the more central terms of crossmedia and transmedia.

Crossmedia started as a term typically used in advertising and the press in order to define the same content or message on different media. However, the term has recently emerged in the context of modern communications research converging with the fields of pervasive computing and human-computer interaction (HCI) (Wiberg *et al*., 2007). Crossmedia has been recently adopted by the informatics area in order to coin media property, services, stories or experiences distributed across media platforms (or devices) using a variety of media forms, but the same fundamental principle remains: the same content or message on different media or devices (Guérin, 2010). According to Boumans (2004) the characteristics of crossmedia include that, more than one medium is involved in supporting a message, story or goal, and that the delivery or support of the common message, story or goal purposefully spans across the different media. Segerståhl (2009) states that crossmedia systems are interactive systems than span across a range of interoperable IT artifacts aiming at providing pervasive and synergistic support for human activities.

For many people, the term crossmedia is used as a synonymous of transmedia (Pasman, 2011). However, for the MIT researcher Professor Henry Jenkins, who massified the use of the terms after publishing in 2003 his *Technology Review* article, "Transmedia Storytelling," that is not exactly true (Jenkins, 2006; 2011). For him, transmedia means different content for different media, each contributing to the creation of a unique final product. Jenkins[4] states that in a transmedia project, the story or experience is spread around a wide range of media platforms, in a way that is complementary where each platform contributes with what it does best. Transmedia Storyteller Jeff Gomez[5] defines it as "the art of conveying messages themes or storylines to mass audiences through the artful and well planned use of multiple media platforms".

As to Guérin (2010) he explains the difference between crossmedia and transmedia in two simple sentences: "*Crossmedia is 100 pieces of a single piece puzzle. Transmedia is 100 different pieces forming a unique puzzle*".

At the beginning, Jenkins (2011) stated that "*Transmedia storytelling represents a process where integral elements of a fiction get dispersed systematically across multiple delivery channels for the purpose of creating* a *unified and coordinated entertainment experience. Ideally, each medium makes its own unique contribution to the unfolding of the story*". However, he also states that new models emerge through production practices and critical debates, and that "*we need to be open to a broad array of variations of what transmedia means in relation to different projects*". So there is no transmedia formula after all. Contrary, "*Transmedia refers to a set of choices made about the best approach to tell a particular story to a particular audience in a particular context depending on the particular resources available to particular producers*" (Jenkins, 2011).

Thus, for the purpose of this work: crossmedia, cross-media, cross-device, cross-platform, multi-platform they all refer to applications, systems or environments that, in the first place extend across a range of different devices as part of a whole system with a structure of roles and functionalities, in order to

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[4] Youtube video: http://www.youtube.com/watch?v=bhGBfuyN5gg

[5] Youtube video: http://www.youtube.com/watch?v=YfH8WwClSx0

achieve specific goals. As to applications, systems or environments they may be presented across devices exactly the same way or in a different way. If through the same way, nothing is changed or adapted across devices. If presented in a different way, the differences may range from simple navigation adaptations (meaning simple changes in interfaces) to different functionalities (meaning that the application is adapted to each device interface and to its specific functionalities taking the best of each device characteristics. Some tasks may spread across devices while others may be available only through specific devices. Synchronization of devices is also a possibility in order to take the best of the integration of devices in a true ecosystem.

2.2.3. Advantages

The major advantage is that crossmedia applications are in accordance with the real world, considering that they are depicting it. According to Jenkins[6] the "*reality is already crossplatform and reality is complex enough to allow us to have many different characters or many different stories on many different platforms*".

These applications are in accordance with the users' needs. As presented previously in section 2.1.2.5., users are revealing an increasing tendency to interactivity and a higher participative attitude.

The use of several devices allows to include a broader range of users considering that they also have their preferences in terms of devices.

Another advantage is that they allow a change of paradigm, in what relates to use. Users are no longer confined to time and space constraints since they have gained mobility.

Crossmedia applications allow covering a series of different contexts of use in the more appropriated way. An example is the use of Facebook, a strong tendency amongst young users that use it everywhere: from the device at hand (Strover & Moner, 2012).

By using more than one device, applications may be designed to take the best advantage of each devices characteristics being used.

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[6] http://www.youtube.com/watch?v=bhGBfuyN5gg

They open doors to a new way of life, considering that, from our research, these applications are extending to all domains (entertainment, information, health, education, and so forth). Examples are presented in section 2.4.

Normally, due to their appeal, mainly in terms of flexibility and mobility, crossmedia applications also have the capacity to motivate those users that are traditionally more resistant to technological innovations (Guérin, 2010).

2.2.4. Challenges

There are many advantages in crossmedia systems, but there are also aspects that affect their efficient use. Crossmedia has been a research area that appeared in the last decade. However, only recently, and mainly through the introduction of the ‘second device’ technology, crossmedia applications started gaining their marketplace. The first essays were very important contributions since they helped: observe users reactions to the new presented technology in general, and to different designs and contexts in particular; perceive users’ needs in terms of applications, functionalities, etc; compare users technological literacy to their attitude in terms of crossmedia adoption; etc. However, users were not prepared to the interaction with different devices simultaneously as they are now, and the design of crossmedia applications is a hard challenge mainly due to the reasons presented next. Challenges are briefly presented here, and they are addressed in more detail in chapter 3 when solutions are discussed.

2.2.4.1. Conceptual Questions

After a detailed study, it was possible to perceive that some of the proposed systems failed because too much effort was put into technical details, leaving behind crossmedia conceptual questions related to interaction design and underlying: cognitive aspects, usability, affectivity, user experience, contextualization, continuity, media technology or devices characteristics. These are the questions that need to be addressed in the first place and lead to one of the contributions of this thesis. After studying each one of these questions, a Conceptual Framework is presented in chapter 3 addressing, in detail, the most important questions to consider when designing crossmedia applications.

2.2.4.2. Different Devices

Crossmedia applications are traditionally cross-platform, multi-platform or multi-device, that is to say, they use different devices. The use of different devices, with different characteristics, functionalities and support for different cognitive modes implies a higher level of difficulty. The application as a whole, and each device interface in particular, has to be designed in accordance with these factors. In spite of a considerable number of basic rules and guidelines that should be considered (Dix *et al*., 2004; Nielsen, 1993; Preece *et al*., 2002; Shneiderman, 1997), designing interfaces for different devices also requires specific guidelines which, in some cases, have been poor especially for mobile devices and TV. Another challenge arises from the fact that these devices technically evolve at different speeds, meaning that some guidelines, directly related to characteristics that are constantly changing (as the screen size and resolution), will soon become obsolete. A more detailed analysis on existent guidelines is presented in section 3.2.4.

2.2.4.3. No Specific Framework or Methodology

There are no specific frameworks or models available for crossmedia design (Pasman, 2011; Paternò & Santoro, 2012; Prata & Chambel, 2012). Some frameworks are available, but only in what refer to devices individually. In what relates to crossmedia design, there are some lines of research, suggestions, concrete contributions but on specific issues and tools, as for instance: the logical framework suggested by Paternò & Santoro (2012) in order to describe the range of possibilities that multi-device user interfaces offer, by identifying ten dimensions that have been judged relevant for such systems; the research questions, related to UX, that should be addresses in crossmedia context (Pierce & Nichols, 2008; Roto, 2006); an initial conceptual framework of cross-platform user experience where PC and mobiles were used (Wäljas *et al*., 2010); the handling of the personalization dimension (Hossain *et al*., 2008; McBurney *et al*., 2007); the assessing of plasticity in terms of design choices in order to improve UI quality. Plasticity refers to “the capacity of user interfaces to withstand variations of context of use while preserving quality in use" (Serna, *et al*. 2010); the software tools that help in the migration of software from one device to another, e.g. adapt a website that was developed to PC in order to be seen through a mobile device, (Ghiani *et al*., 2010; Lin & Landay, 2008; Meskens *et al*., 2008; 2010; Richter, 2005) and a study about the improvement of usability when interfaces are automatically migrated (Nichol's *et al*., 2007). In spite of helping in relation to particular aspects and situations they do not entirely support the challenges and number of variables that arise, as for instance the cognitive dimension, when several devices need to be integrated and synchronized in order to achieve a common goal (Prata & Chambel, 2012). Our contribution was mainly based on proposing a framework which resulted from the identification, study and exploration of the identified relevant conceptual questions. The framework is presented in chapter 3.

2.2.4.4. Usability Problems

These days, it is very common to see users performing their tasks through different devices ranging from the traditional stationary PC to mobile devices with various multimodal interaction resources. However, until now, users' expectations have not yet been adequately fulfilled. Many times this technological offer is not exploited as it should, and when users use crossmedia applications they found several usability[7] issues: "*poor adaptation to the context of use, lack of coordination among tasks performed through different devices, inadequate support for seamless cross-device task performance*" (Paternò & Santoro, 2012). As an example, a potential source of frustration for users is the incapacity to continue performing their tasks when they need to move to another device. In these situations, users either have to manually save the interaction state in the first device and then reconstruct it later on the second device, or, in the worst scenario, users have to start their activities again from scratch when moving to the second device (Paternò & Santoro, 2012). In the previous example, the dominant usability problem is clearly related with continuity, but other problems related with other dimensions of usability are also

[7] Usability is defined by the ISO 9241-11 (1998) standard as "*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*"

frequent, as for instance, the difficulty of browsing the web through mobile devices when websites are used with little adaptation and the frustration of having a smaller number of interaction possibilities when the adaptation is higher. In general, these problems mainly occur due to few research available about crossmedia (Strover & Moner, 2012). This thesis contributes by addressing possible solutions to usability dimensions as continuity, coherence, flexibility, contextualization, and others.

2.2.4.5. Users Resistence

Many users still feel more comfortable with the typical end-user computing environment. In fact, users need to acquire practices in order to manage several devices (Oulasvirta, 2008). This requires additional effort and, there are often tradeoffs between effort and benefit (Segerståhl, 2008). Some studies already mentioned in section 2.1. refer that users less committed to the use of mobile devices, internet and interactivity are the oldest ones and those with lower literacy. It is our belief that the only way to overcome this resistance is by designing true engaging and usable applications with interfaces prepared for more and less technologically literate users. The interfaces will have to be discrete enough to not disturb users when they are not in an interaction mode, and even when they are, 'emergency exits' should be provided to let them easily escape from the application or system. A help functionality may also be implemented. Above all, designers have to keep in mind that a good user experience can make all the difference (Tullis & William, 2008). In order to provide a good user experience a crossmedia application should, for e.g., be able to accommodate changes in cognition modes and different levels of technological literacy, should contextualize viewers in relation to previous usage thus providing continuity, assure a smooth transition between devices, etc. This is true to all users but to the less experienced in particular: a bad design can create barriers to the adoption of the system. One of the biggest mistakes occurs when the designers instead of being focused on the important conceptual questions, are solely focused on technical characteristics. Their main goal is often to present a high tech application, full of features and interactive functionalities. Usually that goal is achieved but the important questions related with conceptual aspects are left behind. As a result, these 'full extra features' applications are too complex even for those who have a considerable technological literacy. More important is that some fundamental issues are sometimes completely left behind: as continuity across devices, coherence, flexibility, personalization, etc. This type of systems will never be adopted by the oldest and least literate users due to their complexity and poor flexibility and personalization. This thesis contributes by addressing the conceptual questions found pertinent to crossmedia design (chapter 3).

2.2.4.6. Producers Lack of Knowledge

In spite of not being a problem everywhere, as stated by (Coll, 2010), in some countries, the majority of the professionals that participated in the first decisional steps of contents production were not profoundly aware of transmedia and crossmedia concepts and their advantages. Some producers assumed that this phenomenon is just a passing phase which will delay their decision to do the 'shift of paradigm' and 'lift off'. Considering that this new paradigm has come to stay, and is gaining space, particularly in youngest generations, any delay in this industry, where everything goes very fast, is a handicap and may be disastrous.

This kind of problem does not occur in some other countries that, as the author states, are "ten year ahead" (Coll, 2010). As to Portugal, and taking into account the new products launched recently to the market by some cable TV providers, we have reasons to believe they are aware at least of some of the trends around convergence. To ignore trends in convergence does not make sense in this era of dematerialization and Internet and, sooner or later, due to the users choices, we believe that the industry, in general, will perceive that they need to 'follow the flow'. However, even having countries in different stages of adoption, since crossmedia is a recent trend, it is important to provide content producers with consistent methodologies, frameworks, guidelines and tools, meaning that any research in this direction will be useful. In fact, as stated by Strover & Moner (2012), given the complexities of crossmedia environments, researchers have only begun to handle with the dynamics of this modern media usage.

2.2.4.7. Terminology

When addressing crossmedia, some important terms become inadequate or too limitative. In fact, the term ‘user’ is associated to the use of applications, media or specific devices as laptops and mobile devices. When using a PC to browse the web or write an e-mail the term is also ‘user’. When referring to TV the term is usually ‘viewer’, ‘spectator’ or ‘TV audience’. So, we will probably witness the raising of a new specific term or an aggregation of existent terms for those who use crossmedia applications. ‘Active viewers’ (Guérin, 2010) and ‘Viewers/Users’ (Strover & Moner, 2012) are two possibilities.

2.3. Supporting Learning

Learning refers to acquiring new, or modifying existing, knowledge, behaviors, skills, values, competences, preferences, etc, and may involve synthesizing different types of information delivered through different supports (Eaton, 2010).

Learning may be classified taking into account different perspectives. Following the Organisation for Economic Co-operation and Development (OECD), an international economic organization of 34 countries founded in 1961 to stimulate economic progress and world trade, there are three forms of learning: formal, non-formal and Informal learning.

Formal learning refers to the learning that is typically provided by an institution (education or training), is structured (in terms of learning objectives, time or support) and leads to certification. Formal learning is intentional from the learner’s perspective (Cedefop, 2001; Eaton, 2010).

Non-formal learning is a type of learning between formal and informal learning. It occurs in a formal learning environment, but that is not formally recognized and may, or not, lead to some sort of specific certification. Typically involves workshops, community courses, interest based courses, short courses, or conference style seminars. The learning takes place in a formal setting such as an educational organization, but is not formally recognized within a curriculum or syllabus framework (Eaton, 2010). The learner’s objectives may be to increase skills and knowledge, as well as to experience the emotional rewards associated with increased love for a subject or increased passion for learning. Examples of non-formal learning include learn-to-swim programs, sports or fitness programs, programs developed by organizations such as the scouts, professional conferences and continued professional development.

Informal learning results from daily life activities related to work, family or leisure. It usually takes place outside educational institutions; it is not structured (in terms of learning objectives, time or support) and typically does not lead to certification (Cedefop, 2013). Instead, it may occur anywhere: at home, work, and through daily interactions and shared relationships among people. For many learners, this includes language acquisition, cultural norms and manners. Informal learning for young people is an ongoing process that also occurs in a variety of places, such as out of school time (Cross, 2007). In the context of corporate training and education, the term informal learning is widely used to describe the many forms of learning that takes place independently from instructor-led programs: books, self-study programs, performance support materials and systems, coaching, communities of practice, and expert directories (McGivney, 1999). Informal learning may be intentional but in most cases it is not-intentional, in other words, it is incidental, random (Cedefop 2013). In sum, informal learning may be characterized as follows (Eaton, 2010):

a) It usually takes place outside educational or training institutions;

b) It does not follow a specific curriculum and is not professionally organized. Instead, it occurs accidentally, sporadically, in association with certain occasions, from changing practical requirements, from daily activities;

c) It is not planned, pedagogically conscious, systematized, test and qualification-oriented, but rather unconsciously, accidental, holistically problem-related;

d) It is experienced directly in its "natural" function of everyday life;

e) It is often spontaneous.

This is when characterized in global terms. However, learning may also be characterized taking into account other factors as, for instance, the technology used to support it and, when that happens, different buzzwords come up, as: e-learning b-learning, m-learning, t-learning, etc. As to e-learning (electronic learning) it refers to the use of electronic media and information and communication technologies (ICT) in education, but it can also be used in conjunction with face-to-face teaching, in which case the term blended learning (b-learning) is commonly used. As to m-learning (mobile learning), is a subset of e-learning that focuses on learning across contexts and learning with mobile devices, thus providing learners with flexibility considering that they may learn anywhere and at any time (Clark & Mayer, 2011). As stated by Bates (2003), t-learning refers to learning environments made available through iTV or TV with an internet connection (which is pretty much the same). Its main advantage is to provide the viewer with learning from home and through well-known equipment.

In the case of this thesis the type of learning addressed is mainly informal, and a mix of e, m, b and t-learning.

2.4. Related Work

This section starts with an historical perspective of access to information through iTV and presents the more relevant research studies, namely those systems where the additional related indexed information was based on video, and those where iTV has been used with other devices as part of crossmedia environments.

Due to the convergence between TV and the Internet, several research projects appeared in the last few years aimed at finding ways of combining TV and web content, with informational or communicational purposes, solely using iTV or being crossmedia. We refer to some of the more relevant to our work and a comparative discussion on these works vs. our application is also presented.

2.4.1. Access to Information and Socialization through iTV: an Historical Perspective

TV still is the preferred device to watch video. Thus being, TV, through iTV, has been one of the most important devices used in crossmedia systems. Since the work presented in this thesis started from iTV and now remains strongly related to it, it was found pertinent to briefly present the history of iTV which, has stated by Abreu (2007), is full of pitfalls that have dictated a journey of advancements and recoils. This section addresses the main milestones along the way in iTV projects while the aspects more related to crossmedia are presented in section 2.4.3. and 2.4.4.

2.4.1.1. iTV General Historical Perspective

Before 1970: In strict sense, Interactive TV is defined as a TV system that allows the viewer to interact with an application that is simultaneously delivered via a digital network, in addition with the traditional TV signal (Perera, 2002). Many definitions were proposed along the years, and the convergence point seems to rely on a specific 'type' of TV where the viewer as the opportunity to interfere with the TV content. The first 'iTV program' was broadcasted in USA by CBS and was first transmitted on Saturday, October 10th, 1953. It was a black and white first program of a children's series called *Winky Dink and You*, in which a cartoon character named Winky Dink went on dangerous adventures (Lu, 2005). During the show, children would place a sheet of plastic over the TV screen and draw a bridge or a rope in order to save Winky Dink from danger (see Figure 1). At the end of the show, children would also be able to trace letters at the bottom of the screen in order to read the secret messages broadcasted. It was a success that lasted four years (Jaaskelainen, 2000; Lu, 2005).

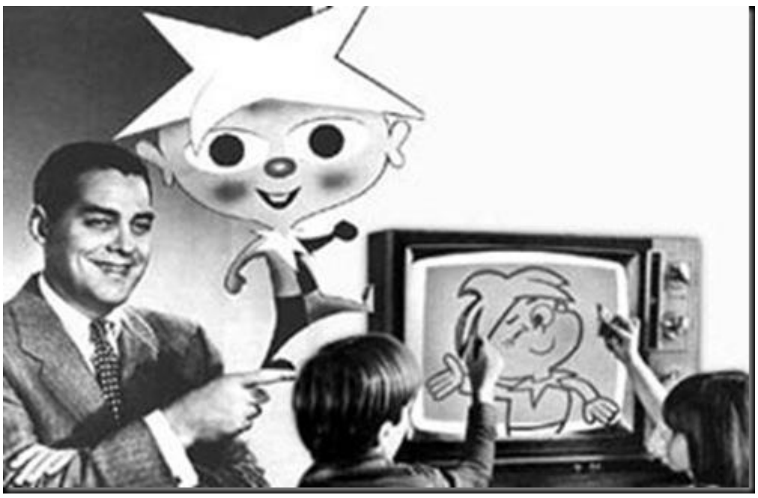


Figure 1. Winky Dink and You
Figure retrieved from (Staten, 2010)

From the 1960s milestones of interactivity, the following 3 are the most important: first, the AT&T Company demonstration of a picture telephone at the New York World Fair in 1964 (Jaaskelainen, 2000; Rowe, 2000); second, the “interactive movie”, Lanterna Mágica, which was produced in Czechoslovakia and shown to the public in the Czech Pavilion at the 1967 World Expo in Montreal, Canada (Jaaskelainen, 2000; Laurel, 1991). Third, the realization, by Marshall McLuhan, that television was a “*cool participant medium*” and thus interactivity should be pursuit (McLuhan, 1964). In the late sixties, Lester Wunderman launched a television advertisement which included a free telephone number. It was the first time that telephone was used as a return channel for iTV (Jaaskelainen, 2000).

1970 Decade: In 1972, Cable Television expanded with all its potential providing over than 75 channels, allowing the use of Set-Top Boxes (STB) and making the remote control viewers’ best friend (Lu, 2005). Three years later, with the launch of Home Box Office (HBO), a premium cable television network, the satellite distribution became viable. On December 13, 1975, HBO became the first TV network to broadcast its signals via satellite when it showed the boxing match "Thrilla in Manila" (HBO, 2006).

In 1973, the Ceefax teletext system was presented for the first time in England. The system allowed the transmission of text and graphics to adapted TV sets (Abreu, 2007).

Other iTV systems experimented in the 1970s were the videotex systems. A videotex system (which may also be referred to as viewdata, videotex, videotext or interactive videotext system) is an interactive information system where a user used a hand-held keypad and a television display screen in order to obtain screens of content and information from a centralized database. These screens of content and information were transmitted to the user through the traditional telephone lines or two-way cable (Kyrish, 1996). The more important videotex systems were the Canadian Telidon, the British Viewdata demonstration in 1974 that was officially launched and commercialized in 1979 with the name Prestel, and the French Minitel first experiences in 1978 (later launched in 1982). While a few videotext services remained for a few more years, most were gone by the late 1980s (Finberg, 2003).

In Ohio (USA), in 1977, Warner launched the Qube platform (Freed, 2000) in Abreu (2007). This was, in fact, one of the main and most original iTV milestones. This platform allowed users to send messages to the TV broadcaster in order to participate in polls and vote during TV programs. In spite of being implemented by other TV operators around USA, it was abandoned due to technical problems and the high cost involved.

As to the 1978 Minitel videotext first experiences (see Figure 2), the information search, initially through telephone number and address, was made available through mini TVs. These terminals were financed by France Telecom in order to decrease the costs related to printed telephonic lists (Gawlinski, 2003).

Figure 2. Minitel Interface
Figure retrieved from (Pierre, 2012)

1980 Decade: The previous mentioned videotex systems have encouraged and inspired American media corporations to launch their own trials (Jaaskelainen, 2000). Another reason which highly contributed to the beginning of a bigger investment in iTV trials was the fact that, around 1984, deregulation had accelerated the cable penetration and, by the end of the decade, cable homes had increased to over 50 million homes (Lu, 2005). Thus, in the 1980s, the best known American trials were the Viewtron, Gateway and Prodigy (Case, 1994; Finberg, 2003; Kyrish, 1996) (see Figure 3). Also important to mention that, during this decade, videotext online services for personal computers registered a significant increasing of users and that this service was the ancestor of the well-known AOL (American OnLine) (Abreu, 2007).

In 1988, BBC presented the children series “What's your Story?”. In this program, viewers could telephone in order to provide suggestions about what might happen next, being the best ideas used in the next episodes (Dodson, 2001) in Abreu (2007).

Figure 3. Viewtron Interface showing a bank transaction
Figure retrieved from (AT&T Archives, 1983)

1990 Decade: In the nineties, Interactive TV finally became a buzz-word (Laurel, 1991) and many experiences were made all around the world, later ending disastrously due to the costs involved. It was also during this decade that Internet expanded due to Web Browser creation, by Tim Berners-Lee (Abreu, 2007). Thus, the use of Wen and TV was seen by many organizations as the ideal recipe to the production of iTV platforms.

In November 7, 1991, the *GTE Telephone Operations* was the first US telephone company offering interactive video services via the launch of a specific project named ‘Cerritos Project’ in California. It was the world's first widespread test of interactive video technology and services (TEC, 2006).

In 1992 Your Choice TV (YCTV) - the world's first commercial VOD digital cable service - was launched by John Hendricks from Discovery Communications. It was defined as the “killer application” for interactive TV (Ramkumar, 2006; Schley, 2000).

In 1993 Viacom and the ATT major telephony carrier formed a joint venture in order to trial interactive television in Castro Valley, California. A month after a six-month free trial of the service, more than 90 per cent of the participants purchased a subscription (Carey, 1993).

In 14 December 1994, the Full Service Network (FSN) was launched by Time Warner in Orlando, Florida. The publicity and news around it was enormous since the Time Warner chairman, announced that the system was going to revolutionize television and interpersonal communications. More than 4000 homes had access, through a fibre optical network, to the available services as VOD, teleshopping, games and an EPG. However, the project cost was over 100 million dollars. Thus, and since it was not commercially viable it closed in April 1997 (HKISPA, 1997). Also in 1994, The Rochester Telephone Corporation demonstrated, via a live test in 100 homes of Rochester, New York, that VOD was not just a dream (NYT, 1994).

In 1995, with the help of digital Satellites, TV could expand to 500 channels. It was a success since, until the end of the decade, millions of dishes were sold. As a consequence, and in order to manage that amount of available channels, the enhanced program guide (EPG) became a necessity (Lu, 2005). Only after 1995, strategic alliances started being formed between the TV industry leaders and thus started the real competitiveness around iTV (Lu, 2005).

The American WebTV solution launched in 1996, the largest web service on TV (WebTV, 2006), was a pioneer system, which enabled users to access the Internet, via a television receptor and a telephone line, while watching TV. We are not in the presence of a crossmedia system but, through the TV, users can send and receive e-mail, use live chats, shop online, and browse the Internet while also watching TV (see Figure 4). In 2001, the subscriber base was sold to Microsoft, latter integrated in the MSTV platform, and the corporation was dissolved.

During the second half of this decade, several television channels (MTV, channel 4, and others) developed programs that displayed what was happening through live chats related to the TV program. These were the first examples of the so called iTV in two screens (Krause, 2003) in Abreu (2007). Viewers were watching TV and simultaneously using the network connected computer in order to, somehow, interact with the program or other viewers.

In spite of the many failures along the way, all the experiences made showed an important potential and allowed consolidating knowledge in this area. By the end of the decade the technological improvements, articulated with the acquired knowledge, finally allowed starting the implementation of iTV more viable solutions (Abreu, 2007). Thus, the following events were also important milestones (Gawlinski, 2003):

In 1996, the French TSP (Television Par Satellite) becomes the first TV station to launch totally digital interactive systems, followed by Channel+. The WorldGate Inc., considered a pioneer in the emerging interactive television space, and America Online TV (AOLTV) soon exceeded 1.5 million viewers (Lu, 2005). The system allowed viewers to toggle between television broadcasting and Internet content instantaneously (BW, 2000).

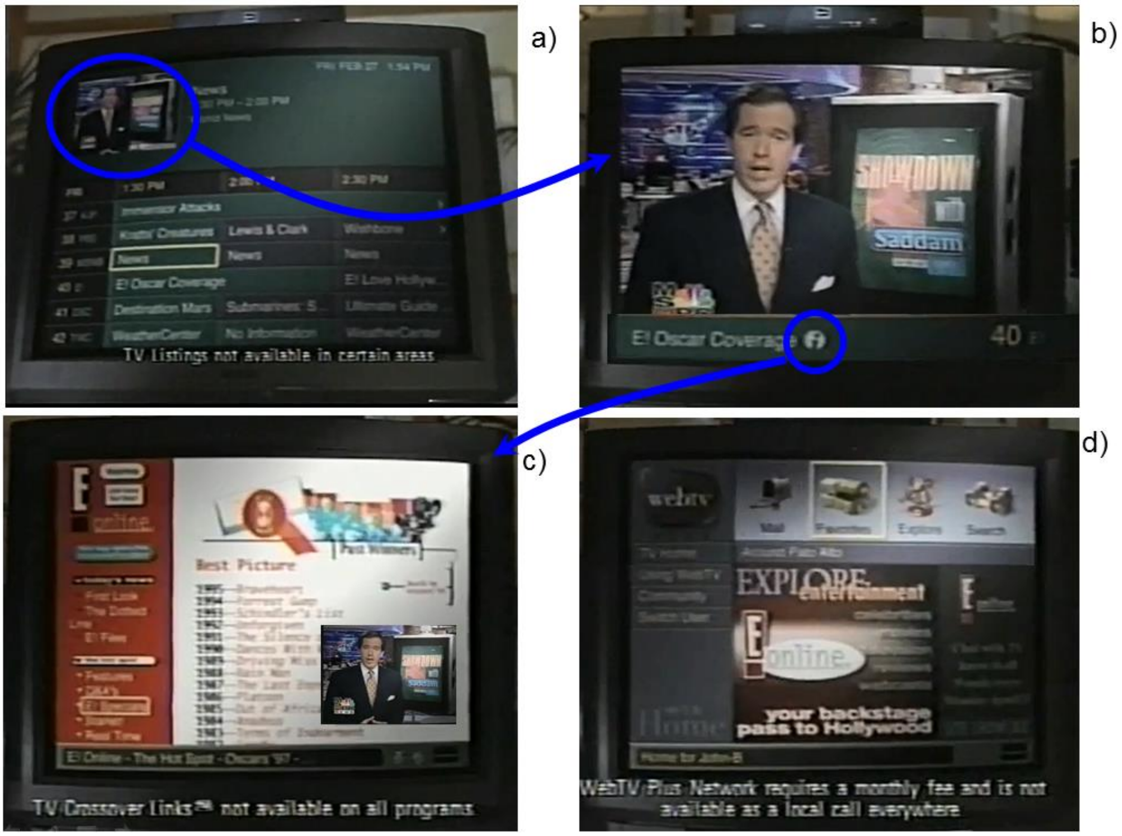


Figure 4. WebTV Interface

a) Full list programming (on the top left corner the correspondent video thumbnail from the selected channel); b) Choosing the channel pulls the video to full screen; c) More information on the www about what is being watched (accessed via the selection of the ‘i’ button from the interface presented in b); d) Interface to access internet services: explore, e-mails, chat, shop online, etc.
Adapted with Figures retrieved from (WebTv, 1996)

In 1998, the British Sky Digital launched a 140 channel service, through satellite, with an EPG and a teleshopping service. The Digital Cable Multiple Systems Operators (MSOs) started expanding the digital infrastructure to over 1.5 Million homes, giving customers potential access to iTV services. By the end of 1990's, that number grew to more than 5 Million (Lu, 2005).

In 1999, Cable & Wireless (now part of the NTL) already counted 10.000 subscribers with interactive services access; also in 1999, Sky Digital implements a service of enhanced TV which allows viewers with the possibility to watch highlights and replays, access statistics and choose different camera angles while watching a football game.

2000 Decade: In 2001, a real iTV Deployment started and iTV soon became a reality in over 6 Million homes. It was time for important strategic alliances between OpenTV, Liberate, Channel+, and WorldGate (Lu, 2005). VOD deployments expanded in the cable world, laying the digital infrastructure necessary for new interactive applications. Satellite providers pushed new iTV enabled projects and PVR's. Two-screen synchronous programming became a necessary option to sports and event programming. At that time, over 40 Million homes had boxes capable of some sort of interactivity and thus Organizations of media, telecommunications and software started real investments in iTV (Chester *et al*., 2001).

In early 2000, Microsoft launched the MSTV platforms which offers software technology, design, and functionality to help network operators deliver the differentiated TV experiences to their customers. In 2005, the Multimedia Home Platform (MHP), a standard developed by the Digital Video Broadcasting (DVB) Consortium, was launched. The standard was gaining worldwide acceptance as one of the technical solutions that would shape the future of Interactive Digital TV. In 2005, the UK was the European leader of iTV, with 73,3% of all houses having digital television, but did not meet the expectations (OFCOM, 2006).

Technological advances allowed the implementation of iTV platforms that failed and closed around 2002. The most commonly referred reason for the telecommunications and cable corporation trials failure was the cost and not viewers acceptance which was good in most situations. The tested services included "movies-on-demand (now called VOD), walled-garden services featuring news and personal information portals, interactive gaming, home shopping, commerce applications, and interactive educational programming" (Swedlow, 2000). From Winky Dink and You, it was possible to learn that technology is not everything, we do not always need a high bandwidth network and supercomputers in order to make compelling interactive systems. From an historical perspective, it was possible to perceive that the incubation period of a new medium can be quite long (Gates, 1996; Negroponte, 1996). As to Metadata, information about information, is a very important dimension in the development of iTV contents and plays a key role considering that, with thousand available channels, it will be impossible to surf from channel to channel in order to decide what to see (Negroponte, 1996). Also fundamental, to correctly worth the importance of the 'communication-between-people' that becomes possible through iTV in order to take the best advantage from iTV. The iTV operators that survived were the ones capable to learn with negative experiences and shape their services to adapt to the viewers' needs (Cádima, 2004a) in Abreu (2007).

In early 2000, viewers already needed to engage in lifelong learning in order to succeed. Thus, iTV operators started providing a solution to accommodate learning situations through the use of T-learning: learning environments made available through iTV. Its main advantage is to provide the viewer with learning from home and through well-known equipment (Bates, 2003). As to other advantages: there is, at least, a TV set in almost every home meaning that T-learning may achieve a vast audience and practically everyone, independently of their technological literacy, that knows how to use a TV set. A full list of T-learning examples may be found at (PJB, 2004a). One example is presented in Figure 5 and consists of a video-rich revision tool, available in the UK through Kingston Interactive Television's Broadband, and from which TV students can access the 'BBCi GCSE Bitesize' service but with additional information provided with video-clips as an on-demand service.

The iTV success results from the right combination between technology, applications and contents and its impact is mainly in technological, artistic, economic and social terms (Abreu, 2007). As to the social aspect, the most relevant to this thesis refers to the possible changes in terms of viewing habits and the most popular type of interactivity. "*Whatever, wherever, whenever...*" a popular expression used by BSkyB in is 2006 annual report showing the trends: "*Viewing habits are changing and so are we. Consumers demand to be able to watch their favourite shows at home or on the move, on the device and at the time of their choosing. Our aim is to deliver the best content to people whether they're watching via satellite, a broadband connection or their mobile phone*" BSkyB (2006). The United Kingdom BSkyB is the main worldwide iTV operator which delivers its own TV channels and interactive services as well as external ones. In spite of being very advanced in what relates to iTV penetration rate and development, United Kingdom was the world leader since 2002 (Quico, 2004).

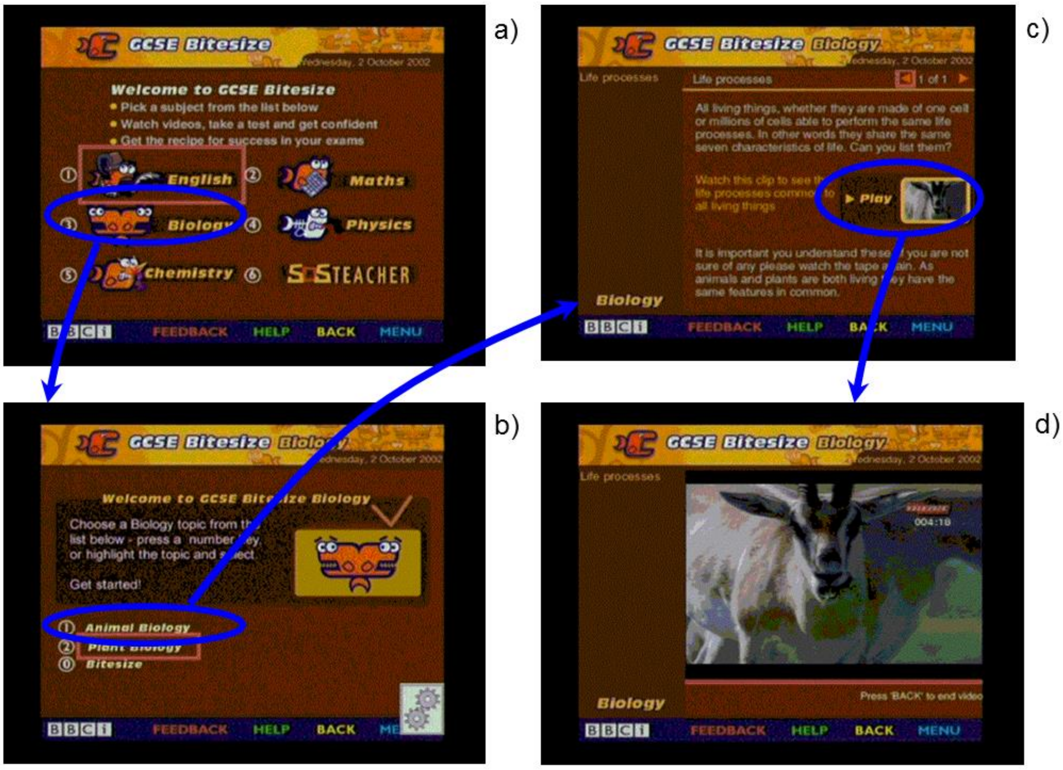


Figure 5. 'BBCi's GCSE Bitesize' Service

a) 'BBCi's GCSE Bitesize' Main Menu on Kingston Interactive Television with 'Biology' option being chosen; b) Inside the Biology option, the 'Animal Biology' option being chosen; c) Inside the 'Animal Biology' option the 'Life Processes' being presented with option to select a video; d) The 'Life Processes' video being played. There is the option to stop, start, rewind and replay the video.
Adapted with Figures retrieved from (PJB, 2004b)

The Portuguese cable provider TV CABO (now ZON) was one of the first in the world to launch, in 7 June 2001, an iTV service and the first in the world to offer the digital video recording functionality through a digital TV decoder box based on the Microsoft TV Advanced platform (Quico, 2008). Some of the services available were: an EPG which allowed to access programs, additional information, search options and programming alerts; communication which allowed sending e-mails, electronic postcards, messages to mobile phones, chat and messenger; shopping which allowed access to several stores, kiosks and promotions; banking which allowed home banking and information about stock market and insurances; internet which allowed access to different services and internet contents, some specifically designed to iTV; journals with information services and multiplayer games. Beyond the referred main services portal, there was also the following: an interactive bar which allowed to access the TV site associated to the channel being viewed, channels programs, programing synopsis, participation in channel quizzes, forums and polls; programs with interactive contents which comprised a set of additional contents thus being considered as enhanced TV through interactive TV programs. Through these contents, it was possible to participate in contests, use multicamera service meaning choosing alternative vision angles during a football match, know more about the characters of a soap opera, express opinions through polls and forums, and to know more about the program participants (presenters and invited), see Figure 6.

Figure 6. TV CABO iTV Service

a) Starting Portal Interface; b) EPG; c) Multi camera service; d) Multiplayer game. Figures a) b) and d) retrieved from (Quico, 2008) and c) retrieved from (Abreu, 2007)

Due to the diversity of contents, it was expected that the platform could be a success. However, by the end of June 2001, in spite of the expected 100.000 users, only 2.500 adhered to the service (Quico, 2008). In June 2003 the TV CABO launched the powerbox, a digital TV service and decoder boxes to satellite and cable clients. The biggest new feature was the ‘pay-per-view’ which the operator decided to commercialize with the name of “video-on-demand” or VOD. However, due to a difficult period in terms of economy, technical problems with the platform, and the public reduced tendency to this type of services, TV CABO was unable to impose its project and in 1 July 2004 the service ended (Anacom, 2004). This pilot experience was an important contribution considering that TV CABO and other providers, as for instance MEO and CLIX, are using the learned lessons in order to improve their services. In fact they opted later by a gradual introduction of novelties and improvements in accordance with subscribers’ receptivity (Marcela, 2007b) in (Quico, 2008), and not yet reaching the same level of service and features as in those days.

Very important during this decade, in spite of previous research experiences, was the tendency to start the use of crossmedia systems as well as the so called first ‘second screen’ in simple ways.

Due to the importance of these systems to the work presented in this thesis, the more relevant related work in these aspects is presented in more detail in specific sections (2.4.3. and 2.4.4.).

2010 Decade: This is the decade when iTV is already enrooted on many viewers’ daily habits (Ostrow, 2010; Paisana & Lima, 2012; Prata, 2008b; Turril & Carter, 2012), as may be seen in more detail in section 2.1.2.1., and the use of crossmedia and second screen systems is expanding due to the new dynamics of entertainment media, specifically the tendency to engage with “television” through different devices (Strover & Moner, 2012; Turril & Carter, 2012), as may be seen in more details in section 2.4.4.

National examples of successful iTV services are proposed by the ZON and MEO service providers, which allow, via a simple click, to access many types of contents through the TV set, as for instance, news, weather, games, quizzes, polls, VOD, etc. These service providers are constantly improving their services and in what relates to the ZON service in concrete, they have received several awards, namely the best iTV interface, and more recently, the service 'ZON IRIS' was considered the product of the year 2013.

An example of National crossmedia, is the recently service MEO GO launched by the MEO operator, which basically allows viewers to watch the same TV content trough TV, PC and mobile phones.

The more relevant related work in these aspects will also be presented in specific separate sections (2.4.3. and 2.4.4.).

2.4.1.2. Socialization through iTV

As previously mentioned, the iTV operators that survived were the ones capable to learn with negative experiences and shape their services to adapt to the viewers' needs. A strong need is the need to socialize, to communicate with others while watching TV. In this area many research works appeared. Two of the most relevant are presented next.

2BEON (Abreu, 2007) is an iTV application, which supports the communication among viewers, allowing them to communicate textually, in real time, while watching a specific program. This application also allows viewers to see which of their contacts are online at a specific moment, and which programs they are watching (due to privacy reasons this functionality may be disconnected) and allows sending video clips (ClipTV functionality) to contacts (see Figure 7). This application allows instant messaging on the iTV, which, as demonstrated, is an important functionality to give viewers a sense of presence. This application, which started as a PhD project, changed its name to WeOnTV and is being implemented with smartphones as "secondary input devices", thus becoming a crossmedia application soon to be distributed by one of the most popular Portuguese TV cable companies (Abreu, 2007). This work shows the importance of the social presence by sharing information with viewer's contacts about what they are watching on the TV. This conclusion was important in the scope of our research, since it contributed to our decision of contemplating sharing functionalities.

Geerts *et al*. (2008) studied a system for sending and receiving enriched video fragments to and from a range of devices, in order to understand which program genres were preferred for talking while watching, talking about after watching and for sending video fragments to viewers with different devices. In terms of system, the basic scenario is that viewers, when watching audiovisual material, may fragment, enrich, and share it with their peers by using an extended remote control such as their mobile phone (see Figure 8 for an example of the media sharing interface).

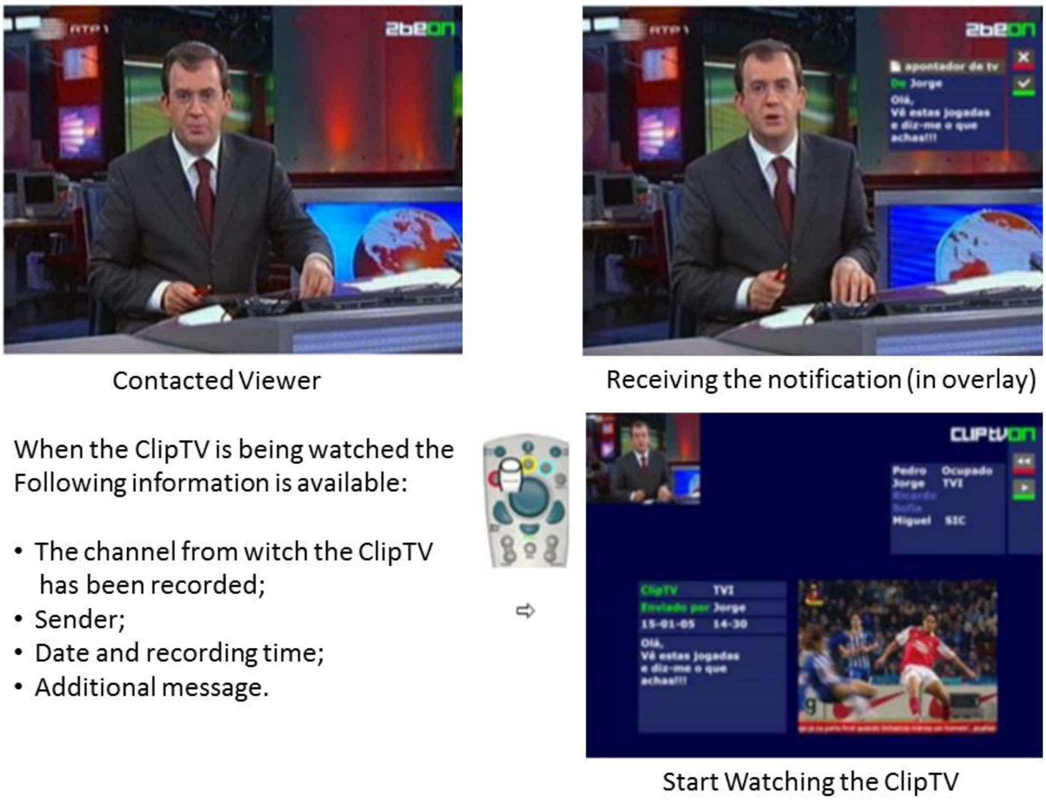


Figure 7. 2BEON ClipTV Functionality

Figure retrieved from (Abreu, 2007)

The results showed that news, soap, quiz and sport were the genres during which the viewers' talk most while watching, thus being appropriate for synchronous social iTV systems. In what relates to asynchronous social iTV, news, film, documentaries and music programs were considered potentially popular genres. As to the case of news, the same number of viewers that like to talk while watching is equivalent to the number of viewers that do not like to talk, being this genre an exception. Soap opera and sports are the genres during which people talk while watching, but also talk about afterwards. As to quizzes, viewers only talk while watching, one explanation might be because they like to show off their knowledge to each other. Concerning devices, documentaries and movies were often mentioned as ‘higher quality content’ which is preferably viewed on television, contrary to the weather or breaking news, which viewers prefer to watch on their mobile phone. Concluding, genres with more ‘plot structure’ are preferred to be watched on TV, while genres with less ‘plot structure’ may be watched on mobile phones. These results were important in the context of our research, since we needed to conceptualize and design interfaces capable to accommodate the different characteristics of each program genre and devices as explained in chapter 3.

Figure 8. Media Sharing Interface
Figure retrieved from (Geerts *et al*., 2008)

2.4.2. TV and Web

This section presents several research studies where TV and Web were successfully integrated. TV is the only device being used, meaning that these systems are not crossmedia or ‘second device’. However, and Independently of being triggered by the web or by the TV content, these systems addressed the need to access extra information in different contexts, which is transportable to crossmedia system, where the access to the extra information is made through different devices.

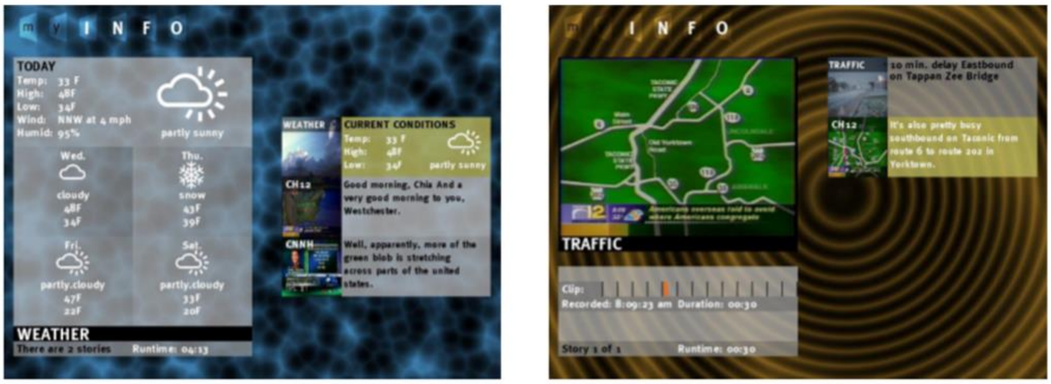
HyperSoap[8] (Dakss *et al*., 1998) explored interaction designs for the iTV paradigm, expecting a more passive audience, and allowing the indication of

[8] http://www.media.mit.edu/hypersoap

interest in topics to be later explored, in a more active and reflective mode at the end of the TV program. It was a soap opera where viewers could select clothing and furniture with a special remote control, and see an item's price and purchase information on a pop-up screen display, thus inquiring and getting external information about purchasing clothes and furniture used in the show. Figure 9 shows an example where the earrings were selected. This pioneer system, developed at MIT Media Lab, explored the need to access further information about a program that is being watched, taking into account users' attitudes while watching TV, just like eiTV does. However, contrary to our application, it was somehow limited considering that the only device used was iTV, instead of a crossmedia environment, and that the additional info had to be accessed at the end of the program and always in the same level of detail.

Figure 9. HyperSoap with earings being selected
Figure retrieved from (Dakss *et al*., n.d.)

Dimitrova *et al*. (2003a) proposed two systems: MyInfo and InfoSip. Myinfo is a personal news application which extracts specific web content listed in the user profile and displays personalized TV news programs - weather, traffic, sports, financial news, headlines, and local events - on the TV and based on the web content (see Figure 10). To access the information, which is related do the program being watched, the viewer only needs to access one of the six mentioned "content zones". In technological terms, the starting point is the web and the arrival is TV (improved with web content) (Haas, *et al*., 2002, Zimmerman *et al*., 2003).



a) b)

Figure 10. MyInfo Interface

a) Info about the weather; b) Info about the traffic
Figure retrieved from (Zimmerman *et al*., 2003)

InfoSip is a movie information retrieval application, which analyzes the movie content and gives audiences information (overlaid on screen) on such things as “who’s the actor?”, “what’s the song?”, “where are they?” In sum, the application answers most frequently asked questions. To access that information, the viewer only needs to press a specific button on the remote. A possible scenario is to be watching a movie and not remember the name of the actress on screen. Through a simple click, the system provides viewers with the name of the actress and all the movies that they have watched and where she participated. As may be seen in Figure 11 the information appears overlaid on screen, allowing viewers to continue watching the movie/TV.

In technological terms, both systems starting and arrival points are TV (with a web information gathering in between). Both systems were developed based on the belief that, while watching a program, the viewer may feel the need to know more about that story, so a content augmentation application could understand which story was on and provide appropriate, personalized, summarized and targeted information and also references, as for instance web links, for further exploration. Both applications offered a new direction for personalization research “where the source of the content is less important than the actual delivered information to the viewer” but both were limited considering that the ‘extra information’ available was previously categorized and limited to a small number of possibilities (Dimitrova *et al*., 2003a; 2003b). As to our eiTV application, it also has an option with pre-defined categorized ‘extra information’. However, viewers have the possibility to go much further considering that, while watching the video, they may choose exactly in which topics they are interested in knowing more about, and almost everything that is present in the subtitles is a possible choice.

Figure 11. InfoSip Interface
Figure retrieved from (Dimitrova *et al*., 2003a)

Ma and Tanaka (2003, 2005) have developed the Webtelop, a “Parallel presentation” system to present the TV program and web content simultaneously on the TV, enabling viewers to browse the web content while watching the TV program (see Figure 12). In practical terms, the system enables viewers to watch a program on television, while complementary web pages are presented simultaneously as captions of the TV programs. As to web pages, which are presented in real time with the TV content, the system searches and presents two types: web contents that provide more detail about the information being presented, and web content with information that allows a broader perspective (this was possible due to a complementary retrieval mechanism used in order to find information similar to the video or TV program, but also additional information that describes the topic from different perspectives). The program and related web pages may be stored via a simple click for later view.

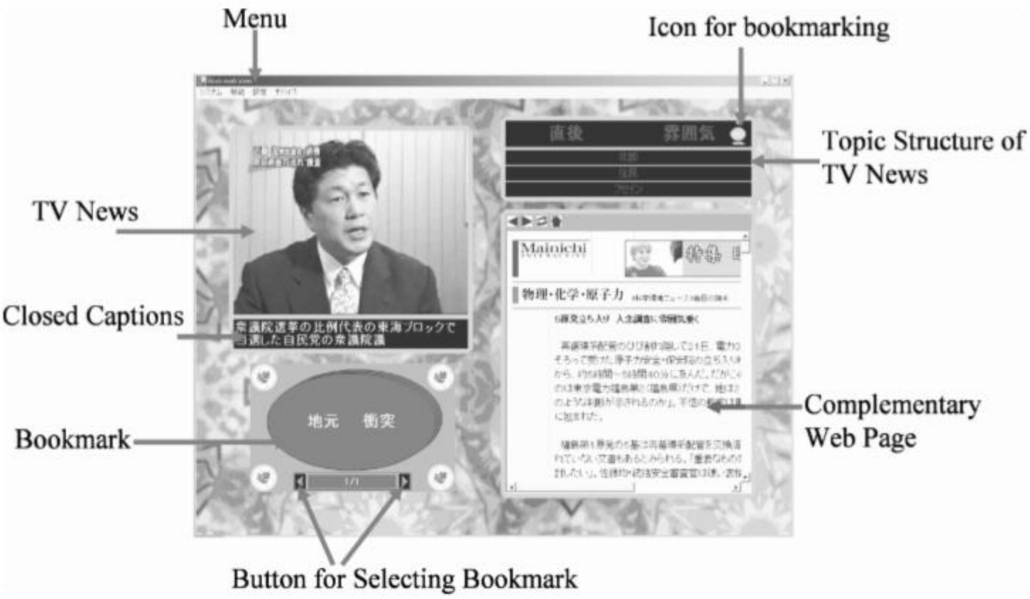


Figure 12. Webtelop User Interface
Figure retrieved from (Ma & Tanaka, 2005)

Viewers are asked to specify the query type in advance. The available queries are CD (content-deepening), SD (subject-deepening), SB (subject-broadening), and CB (content-broadening). Queries may be used together or separately to search for complementary web page, and viewers may specify more than one type of query. To limit the search, they can also specify the news sites that interest them the most. These are the only available possibilities in terms of personalization and flexibility.

In technological terms, both starting and arrival points are TV (with a web information gathering in between). In spite of showing that watching TV and viewing related Web pages at the same time is viable for viewers, the system evaluation revealed a need to further investigate most suitable interfaces. In fact, considering that everything is presented on the TV screen, the system resulted too much intrusive of the TV viewing experience and without addressing viewers' changes in cognitive modes, which may be more passive or active and change in seconds, requiring easily adaptable systems. Our application integrates web content into the TV but on an iTV typical interface with the advantage of offering different levels of information (from more informative and less intrusive to less informative but more intrusive) in order to address viewers changes in cognitive modes. Nevertheless, this system addressed the need to provide viewers with extra content while watching a TV program and contributed with solutions to integrate web content with TV.

A system proposed by Miyamori et al. (Miyamori *et al*., 2005) generates views of TV programs based on viewer's perspectives expressed in live web chats, where they express their emotions about TV programs. In fact, they propose a new video indexing technique based on the view point of the users, collected from their participation in live web chats, where they express their emotions about the TV programs. This work was an attempt to integrate TV and the web in a personalized way and taking into account important dimensions as the emotion and the sense of unity and continuity, considering that when they comment specific excerpts of video, the excerpts are then used to generate the referred views of TV programs (see Figure 13).

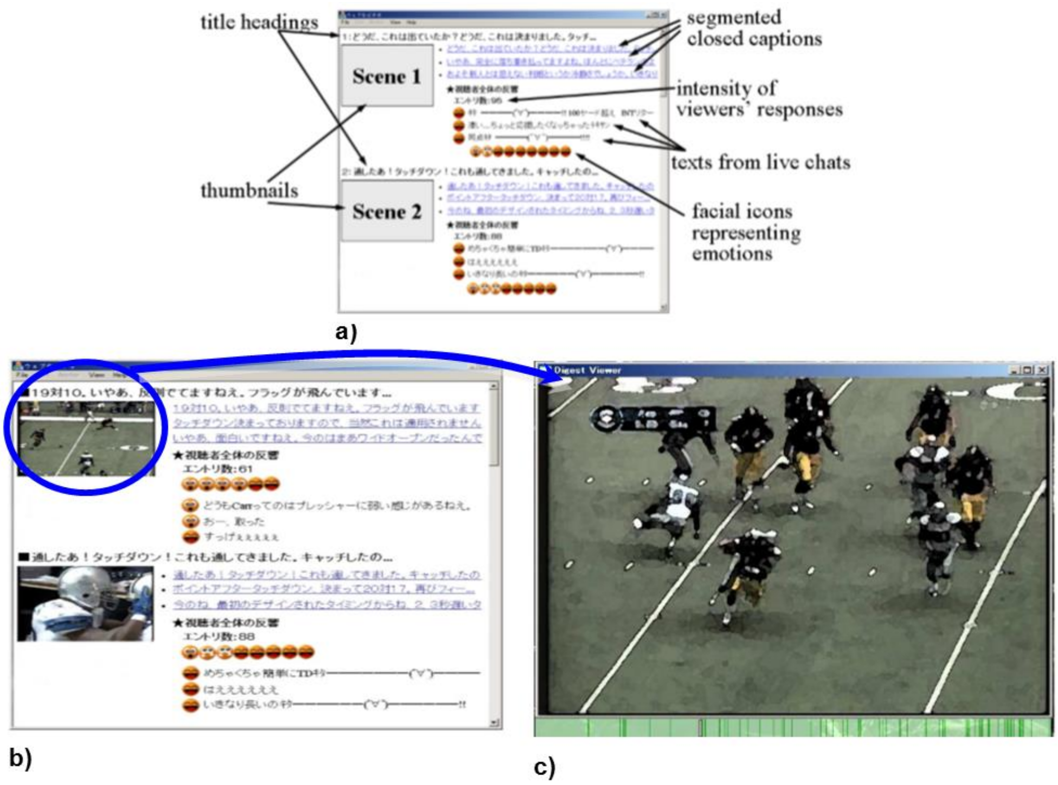


Figure 13. System Interface

a) Example of TV viewing using the authors method; b) Example of chronological news; c) Example of digest generation

Adapted with Figures retrieved from (Miyamori *et al*., 2005)

In general terms, they defended the role of these two dimensions in the design process and the importance of personalizing the TV content, which are in accordance with our own belief and research. However their research strictly relies on viewers' feedback and comments in web live chats, which in spite being the innovation is also the major limitation of the system. In fact, many times due to several reasons, related to social acceptance, and depending on the people that the viewers are talking to, their opinions may not correspond to what they really think and feel. A simple example is to discuss football with the chief through the live chat while watching the game. Thus being, the system may provide them with useless content. That is why in our application, in spite of implementing an automatic personalization feature, the extra contents are presented according to choices specifically made by viewers in private.

2.4.3. Crossmedia Systems

This section specifically presents crossmedia relevant related works, organized by different combinations of devices used, taking into account the conceptual model behind each system. The presented categories are 'PC and mobile', 'TV and mobile', 'TV and PC' and finally ',TV, PC and mobile'.

2.4.3.1. TV and PC

This section presents crossmedia systems where the conceptual model relies on the use of TV and PC, independently on which of the devices is the predominant.

Cronkite (Livingston *et al*., 2003) provides just-in-time extra information to viewers of broadcast news. While viewers are watching a news story on TV, they want to know more about it, they press the "interest" button on their remote control and the system provides them with extra information on the computer display. The extra information, which also comprises pointers to other related stories, is about the story that they are watching, the whole program, 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 (see Figure 14). This work takes the first steps at providing a theory for understanding viewer interaction and information needs while watching television. The system is limited considering that the extra information is not stored for later view (and that could be the viewers' preference: to view the extra information next day, for instance). The paper clearly addresses the need for further similar research in this area but with other program genres, namely documentaries, which was exactly what we did, also expanding the functionalities and without the limitations of the Cronkites system. 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.

Figure 14. Cronkite Interface

Figure retrieved from (Livingston *et al*., 2003)

TV2Web (Sumiya *et al*., 2004) is a method to automatically construct Web content from video streams with metadata. The constructed web content includes thumbnails of video units and caption data generated from metadata (title and text). Figure 15 shows the basic concept behind this crossmedia system that extracts still images and time-code information from an original video stream and its metadata.

Viewers are able to: navigate the content with normal web browsers, zooming the web content to easily change the level of detail of the content being viewed as well as the viewing-oriented control mechanism to dynamically generate adequate text during browsing (see Figure 16) and search for favorite scenes faster than with analog video.

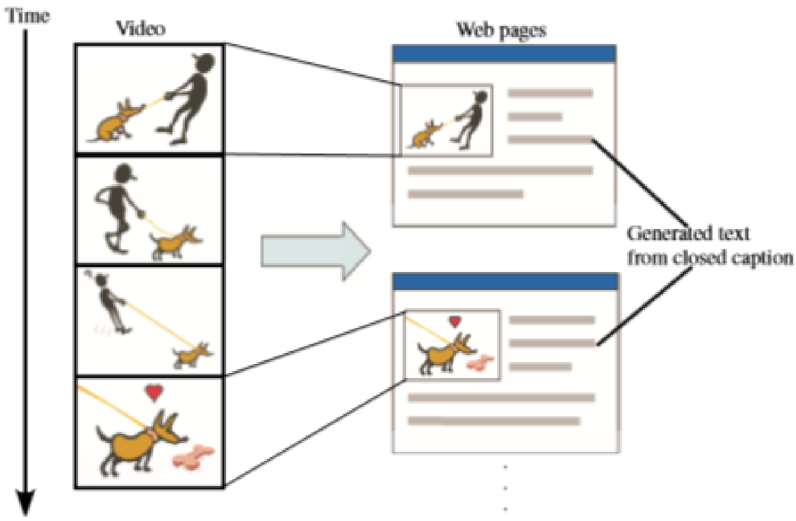


Figure 15. TV2Web Conceptual Model
Figure retrieved from (Sumiya, *et al*., 2004)

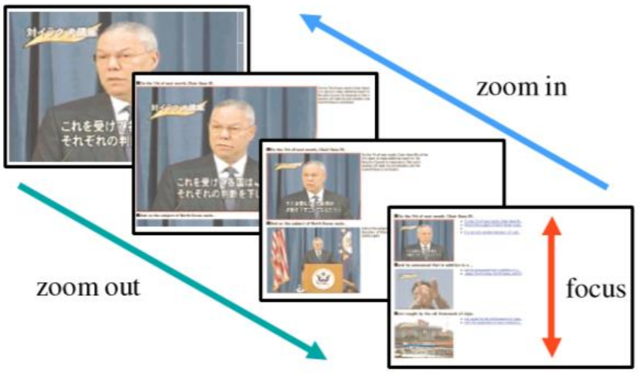


Figure 16. TV2Web Zooming Function
Figure retrieved from (Sumiya, *et al*., 2004)

Viewers may interact with the web content by easily switching different levels of detail on pages and by selecting a video unit. These interactivities were called zooming and focusing. The levels are dependent on the length of the video units displayed on the Web page. The length of the video units is represented by the sizes of the thumbnails: the larger thumbnail, the longer the video unit. For example, when there are two thumbnails, the semantic scenes are divided into two units. Both units are adjusted to be as equal as possible. Users can initially watch videos at full size on the display. If they zoom out, the video will be divided into two smaller thumbnails, three, four, etc. The more they zoom out, the more the video will be divided into smaller thumbnails.

This approach was interesting, and provides viewers with flexibility considering that they may choose from having the video presented as a whole unit or to have it segmented in several units depending on the zooming level they decide to use. This zooming function allow viewers to have the video divided into small units and directly, easily and faster access the specific ones they want to view. However, it was a limited crossmedia system considering the number of devices involved and interaction possibilities: the amount of extra information associated to the video fragments is limited and is presented to all the video fragments, meaning that personalization, granularity, was not considered at this level. In fact, viewers are unable to select contents along the video. As to our application, it uses video excerpts from the original TV program in order to contextualize the web content in relation to specific chosen topics, not to the whole video. As to the number of devices involved, we have spanned our application across iTV, PC and mobile devices environments.

Miyamori and Tanaka (2005) have developed a ‘Web-browser-style presentation’ system named Webified Video capable to automatically transform traditional TV content into web content and integrating the result with related information such as complementary Web content. The TV content source was transformed into a web presentation and complemented with extra web content which, in general, means an increase of information. In technological terms, the starting point is the TV and the arrival is Web (see Figure 17). The system addressed the need of extra and complementary content to TV namely through web related information. However that happens to the entire TV content and not only to specific topics, as in eiTV. Thus being, the system does not provide viewers with much flexibility and personalization, imposing additional web information to all topics within the TV content. It was also expected that the use of the original TV content into the final application could assure continuity and contextualization. However, sometimes the TV content transformation resulted so profound that became hard to immediately identify which part of the TV content was being addressed in the generated web content. In spite the identified limitations this work was a valuable contribution to our research.

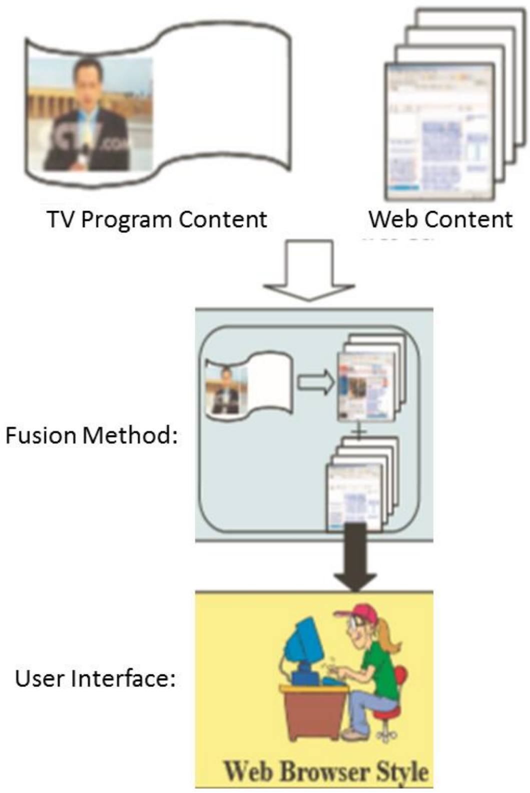


Figure 17. Webified Video Conceptual Model

Figure adapted with figures retrieved from (Nadamoto & Tanaka, 2005)

CoTV™ (CoTV site, 2011) or coactive TV, automatically presents, on a PC, web content related to the on-air program. It acts like a special web search engine that is continuously and automatically driven by the TV-viewing context (not driven by the viewers' actions). CoTV™ also includes a portal with traditional iTV services, as for instance program guides, video-on-demand, DVR scheduling, etc. (see Figure 18). Due to their characteristics, and contrary to eiTV, this system does not provided a personalized adequate answer to viewers needs while accommodating their changes in cognition modes. However, it addressed the need to provide viewers with extra content while watching a TV program and contributed with solutions to integrate web content with TV in a synchronized fashion.

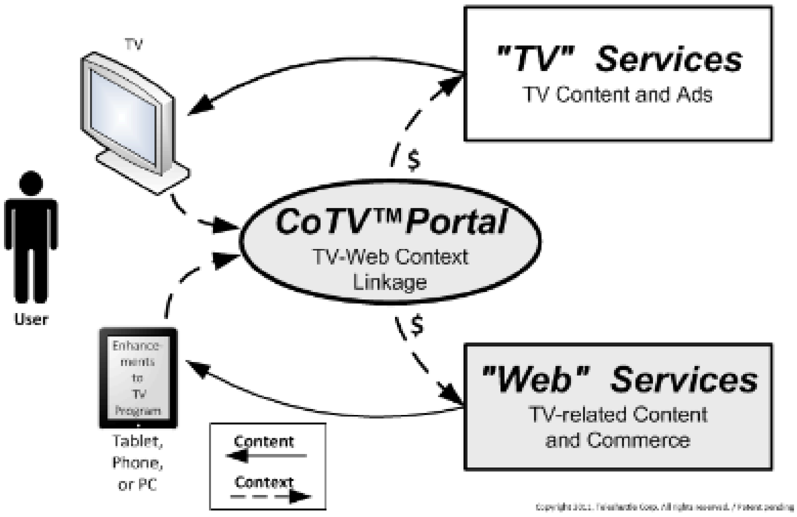


Figure 18. CoTV Conceptual Model
Figure retrieved from (Teleshuttle, 2011)

2.4.3.2. TV and Mobile

This section aggregates crossmedia systems where the conceptual model relies in the use of TV and mobile devices, independently on which of the devices is the predominant.

A museum guide named Cicero (Ghiani *et al*., 2009) was developed by the Human-Computer Interaction Group of the HIIS Lab of ISTI-CNR in Pisa. This project is a multi-device, location-aware museum guide, capable to exploit opportunistically large screens when the users are nearby. Several types of games (both individual and collaborative) have been associated with the descriptions of the artworks, in order to enrich the users' experience during their visits, by helping them to learn more. In technical terms, the mobile device is equipped with an RFID reader able to identify the artworks which are near the user through the RFID tags associated to the various artworks. One of the main advantages of this guide is the capability of exploring multi-device environments in which the users are free to move around with their guide mobile devices and, opportunistically, use large screens for collaborative activities, when they are nearby (see Figure 19). Another advantage is that the availability of large screens and the use of collaborative games within the museum stimulate the social interaction between users. This will improve the assimilation of the contents associated with the museum, considering that through the games users will learn while entertaining and they are also pushed to interact with other visitors. The guide also provides personalized information to users, thus improving their experience during the visit, by exploiting context-dependent information (e.g. the current position of the users, the history of their interactions with the application, the currently available devices, etc.). This work was implemented in two museums: the Marble Museum of Carrara and the Natural History Museum of Calci (near Pisa).

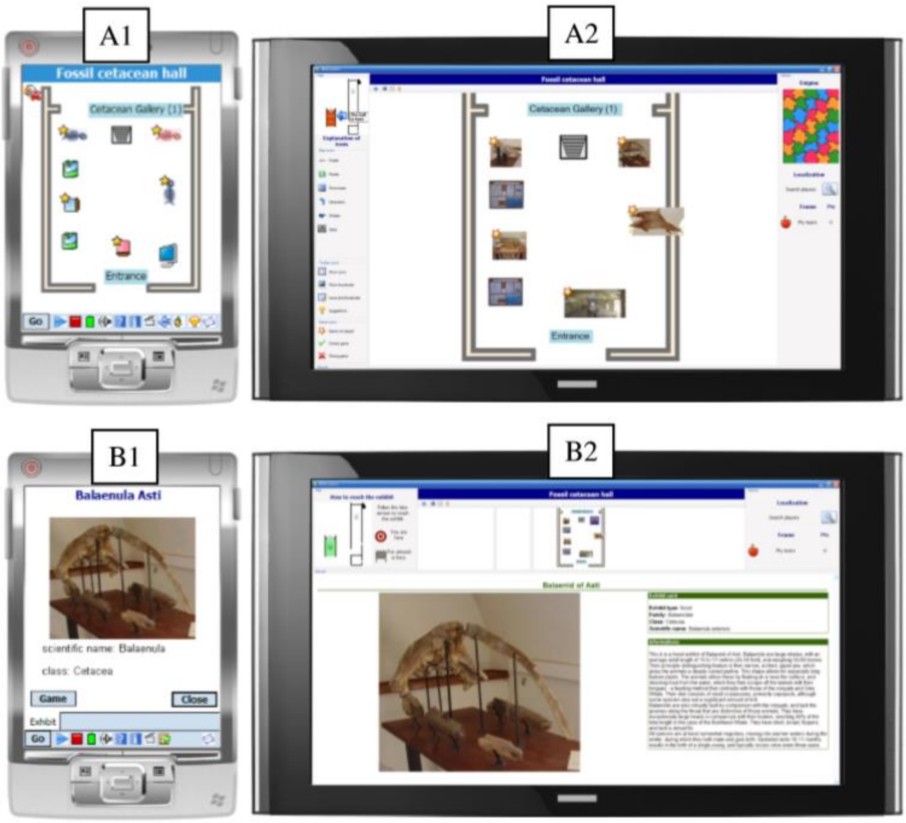


Figure 19. Cicero device dependent representations

A1) Virtual section on PDA; A2); Virtual section on large screen; B1) Artwork preview on PDA; B2) Large screen.
Figure retrieved from (Ghiani *et al*., 2009)

This system addresses the need for extra and personalized information, the importance to take the best of each device and the role of interaction with others and with the application via individual and collaborative. However it was limited considering that the extra information strategies, made available to help viewers assimilate contents, were developed for immediate consumption and restricted to that particular spot. In our application, the extra information is stored for later view and may be shared, edited, etc. whenever the viewer decides to.

The crossmedia TAMALLE project (Pemberton & Fallahkhair, 2005) developed a ‘dual device system’ for informal language learning, based on iTV and mobile phones, supporting learners of English as a second language in their TV viewing, and allowing selecting what to access later on the mobile phone (see Figure 20). This was an interesting crossmedia system capable to accommodate different cognitive modes, since it was prepared to provide different types of information to be accessed in two devices that typically require different cognitive modes. The system was flexible and able to accommodate different contexts of use due to the combination of these two different devices. This work was important to our research due to the good results achieved by providing users with mobility in the use of the system. However it is more limited in options and scope, considering that the only output device was the mobile phone, only used as an output device, and thus functionalities in order to take the best advantage on the mobile phone characteristics were not considered.

Figure 20. TAMALLE Interface
Figure retrieved from (Pemberton & Fallahkhair, 2005)

To illustrate emerging trends, we refer to a project that aims to support and involve viewers with TV content in more active ways. The iDTV-HEALTH (Damásio, 2010) explores inclusive ways to promote health and wellness via iTV. The project main goal is to evaluate the potential of digital interactive television (iDTV) to promote original services, formats and contents that can be relevant to support personal health care and wellness of individuals over 55 years of age. It is a crossmedia project since the intention is to develop an iDTV portal solution: a portal with video content, still images and text, with associated navigation system both for IPTV and mobile. Considering that this study was exploratory, no pictures were available. This is an important study considering that it addresses an oldest target population, those typically less technological literate and thus less committed with the use of new technologies and with special needs. Thus being, the results achieved may be important and a step further in order to help understand with what and how it is possible to engage this population, in terms of contents, and in terms of acceptance strategies.

2.4.3.3. PC and Mobile

This section is dedicated to crossmedia systems, where the conceptual model relies on the use of PC and mobile devices.

Segerståhl (2008; 2009) proposed the 'Polar Fitness System' a crossmedia fitness support system, which includes a wearable heart rate monitor and an interoperable web service. Along with the heart rate monitor, accessories such as a GPS receiver, a heart rate monitoring strap, and a USB dock for transferring data to the web are included. The wrist unit provides immediate information (during the exercise) on factors such as heart rate, calories, time and distance and tools for planning, monitoring and following-up fitness activities. After each exercise, the wrist unit provides feedback as well as a weekly summary with suggestions for the next week. The web service, that is supposed to be accessed through the PC, includes a training calendar and tools for creating long-term training programs as well as detailed exercise plans, and "information and instructions for heart-rate-based exercise. It also provides progress charts, graphs and summaries for analytic and long-term follow up, a place to document exercising and a long-term storage for exercise data" (Segerståhl, 2009). In sum, in order to access the complete information, users are supposed to access the web service. Figure 21 illustrates how the system and its components are supposed to integrate, while Figure 22 shows the fitness system components.

The crossmedia fitness system was an interesting contribution but did not achieve all its goals. As it was used, the system even changed the ways in which subjects trained, and in some cases even their main goals. For example, a participant found out how he could use the collected heart rate information in order to regulate his recovery times between weight lifting sets while training, meaning that the wrist unit by itself succeeded. However the system was not perceived by all users as crossmedia, because the system was not presented as a whole unit. Since the wrist unit interface was not designed in a way that reminded the user that a web service was available, the contextualization failed.

Figure 21. The Polar Fitness system provides support for planning and follow-up via its components.

Figure retrieved from (Segerståhl, 2009)

Figure 22. Fitness System components: wrist unit, web service and data collection Accessories.

Figure retrieved from (Segerståhl, 2008)

This work was an important contribution considering that it helped showing the importance of presenting the system as a whole unit, something that needs to be understood by viewers since the first moment, thus making part of their conceptual image of the system. Another relevant dimension is contextualization which failed in the system and must be assured in order to keep viewers aware of contents amongst transitions.

2.4.3.4. TV, PC and Mobile

This section discusses crossmedia systems where the conceptual model relies on the use of TV, PC and mobile devices, independently on which of the devices is the predominant.

Nadamoto and Tanaka (2005) have developed ways to automatically transform web content into TV-program-type content as a first step towards media fusion. As to the generated TV-program-type content, in spite of being presented in TV style, it may be watched from TV, PC and mobile phones. Their transformation systems are based on creating audio and visual components. In this work they used “text read-out and dialogue techniques for transforming the audio component, and image animation and character agent animation types for the visual component”. By combining these techniques, they were able to transform web content into various types of TV program content, which may be fused with various broadcast programs and watched from any device. In sum, they have proposed a ‘TV-style presentation’ system capable of searching the web, extracting related and relevant web pages, automatically transforming the text and image based web content found into audio-visual TV - program type content - through the use of character animated agents and text read-out; and fusing it with normal broadcasted TV program contents. In technological terms, starting points are TV and web and arrival points are TV, PC and mobile phones.

They have developed three prototypes which operate as follows: “u-Pav reads out text in web content and presents image animation along with text and keywords by ticker; Web2TV reads out text in web content, automatically allocates the text in web content to several character agents, and presents images synchronized with the characters’ speech; and Web2Talkshow transforms summarized text in web content into a humorous character agent dialogue and presents character agent animation synchronized with the agents’ dialogue” (Nadamoto & Tanaka, 2005) (see Figure 23). This work addressed the need for extra and complementary content, however that content was transformed in order to be integrated with the information source. The results have shown the usefulness of their approach, and also the need to refine the fusion of transformed web content with TV program content. In fact, the final result became too much too intrusive, and, contrary to our application, the authors are not offering a personalized solution prepared to react to changes in viewers' cognitive modes, which may be more passive or active and change in seconds, requiring easily adaptable systems.

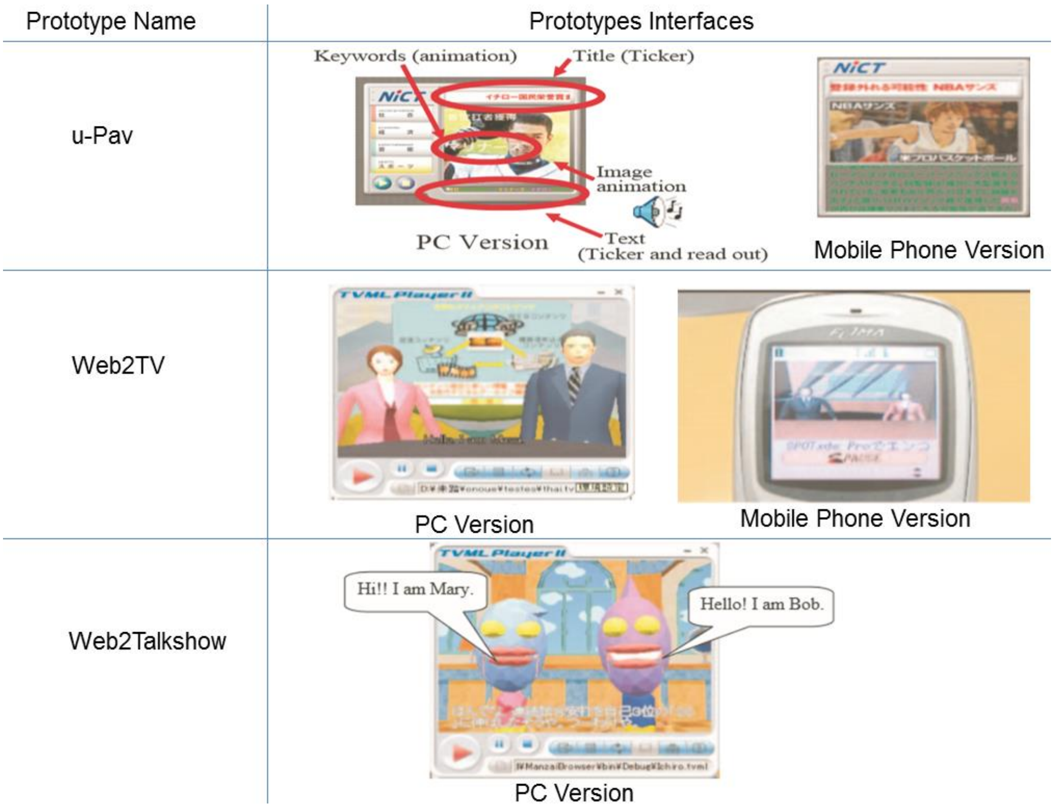


Figure 23. 'TV-style presentation' system prototypes
Figure adapted with Figures retrieved from (Nadamoto & Tanaka, 2005)

Newstream, developed by Martin *et al*. (2010), delivers a crossmedia (video, audio, text,…), socially aware news experience, focusing on relating virtually identical and similar content across different media, community and personalized filtering, social dialogs, and multiple device delivery and interaction, delivering news stories through dynamically generated streams (stream is a sequence of news-related video clips, audio clips, text-based articles, or interactive experiences, aggregated according to specific themes, such as entertainment, politics, or technology). The system provides extra information about what is being watched on the news and about related websites, using TV, PC and mobiles. The extra information may be of two types: directly related to the specific story that the user viewed, thus allowing an expanded view, or information that allows exploring similar content that does not expand on the same story but expands the background or horizon of a similar type of story. In order to choose the extra information, Newstream starts by looking at a larger community to determine the most popular or relevant pieces of information within a specific geography, interest group, or topic. At its most basic, the system builds a stream of news content starting from most popular to least popular within this network, where popularity is only defined by the amount of views. The Newstream interface also allows a user too specifically like, dislike, and favorite content. Depending on viewers' needs, that extra information may be viewed immediately, stored for later view or pushed to another device. All devices maintain 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 standalone interface, as a remote for the TV (or PC), allowing a user to navigate content streams synchronously across the devices (see Figure 24). Limitations, in spite of the technically well designed "ecosystem of devices", are the fact that, the system relies almost exclusively on social networks to receive and share content, as well as for interaction and dialogues, and the limited viewer direct influence on the new content presented as extra information. In fact, that content is presented based on the whole story that the viewer is watching and not particular issues within that story.

What distinguishes eiTV from Newstream is the viewers' possibility to choose exactly which issues they are interest in knowing more about, the ability to generate that extra information, which may be edited and complemented with the viewers' input (text, images, video, music), the fact that the system does not rely on social networks, in spite of having the possibility to share those extra contents with social networks contacts (if the viewer has them), and is not limited to a single genre, it was already implemented on two different genres: documentaries and film series. As to functionalities, in Newstream they are very different between devices. TV is used to watch videos and the mobile phone interface has five tabs: one that allows using it synchronized as a remote control for TV or PC, and four other tabs entirely focused on the community built around the video, and act independently of the TV interface. This allows viewers to interact with their social network, find new media, and browse different clips, all without affecting the content shown on the TV. As to eiTV, all the devices are prepared with the same basic features in spite of some devices specific features.

Figure 24. Newstream user interface across multiple devices
Figure retrieved from (Martin *et al*., 2010)

Obrist *et al*. (2010) developed a crossmedia “6 key navigation model” and its interface for an electronic program guide (EPG) running on the TV, PC and mobile phone. The different devices were not used in a complementary way. In fact, the intention was basically to test a similar interface, on three different devices, which was based solely on six specific keys (illustrated in Figure 25). They have reached important results since they have perceived what works best and what does not work. In particular, that viewers prefer a reduced number of navigation keys and a unified User Interface (UI) with the same functionalities across devices. This was an important contribution to our research, reinforcing the need for a reduced number of navigation keys and consistency across devices.

Figure 25. The 6 Key Navigation Model for the mobile phone, TV and PC

Figure retrieved from (Obrist *et al*., 2010)

Mirlacher *et al*. (2010) compared three different iTV interface designs which main goal was to simplify the interaction and also minimize the number of remote keys used. They presented three different concepts: the "look there" concept which used six keys, the "up-down" concept that used four keys, and the "black hole" concept that also used four keys (Figure 26).

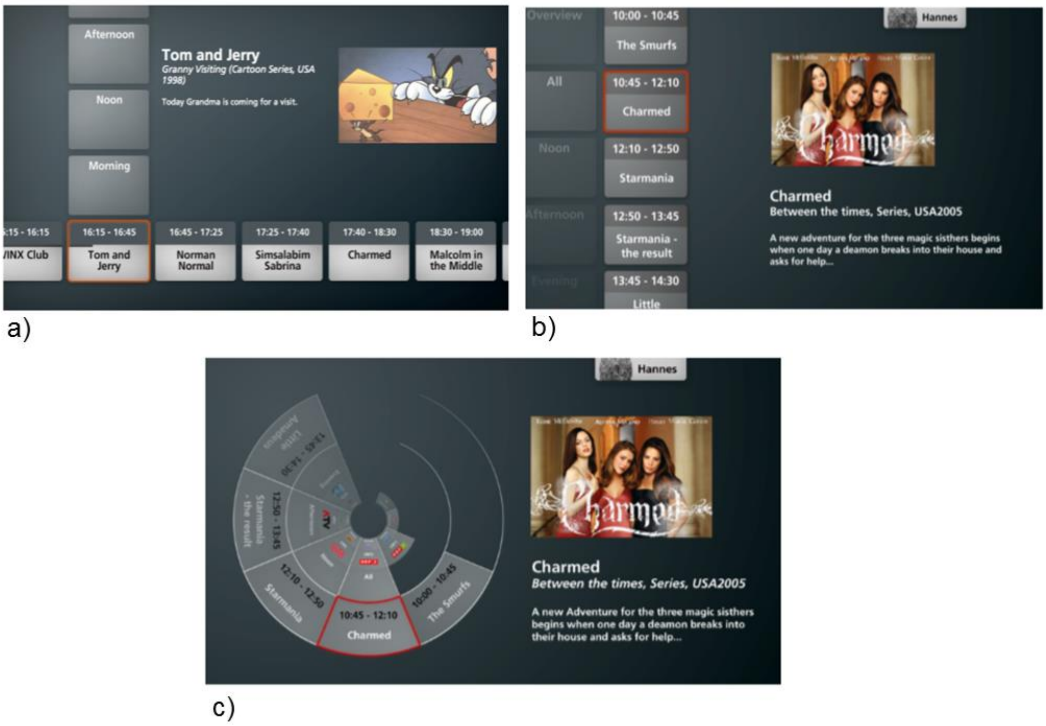


Figure 26. Proposed EPG three different interfaces

a) Screenshot of the "look there" concept displaying an EPG with the TV program and the times of the day for a specified channel; b) Screenshot of the "up-down" Concept displaying the EPG; c) Screenshot of the "black hole" concept showing the detailed view of one show on the EPG. Figure adapted with Figures retrieved from (Mirlacher *et al*., 2010)

As a result, the six key “look there” concept was the favorite and the one that performed best in terms of task completion time and navigation orientation, in spite of being the concept which comprised more keys. This study showed that it is important to have a reduced number of navigation keys. However, that does not mean that the interface which requires a lower number of keys will necessarily be the preferred one and the more effective. This indicates that a balanced solution between effectiveness and usability should be found. The authors also state that the concept also shows its advantage in allowing crossmedia usage, namely, the navigation concept use on PCs and mobile devices.

2.4.4. Second Screen Systems

This section presents second screen systems, which Imply the use of TV as main source of information and the simultaneous use of other devices, e.g. smartphones, laptops, tablets, as companion, in order to allow viewers interaction with the TV content. In spite of being crossmedia, they were considered in a different section precisely due to this particularity simultaneous use.

The NoTube project (Aroyo, 2012) where a second screen system uses the web as a useful companion to the TV, had the vision of bringing Web and TV closer together via shared data models and content across multiple devices. The system exploits the richness of data on the Web in order to enhance the TV experience. Social web viewers’ activities are analyzed to create continuously evolving user profiles and, based on that, the system is able to recommend interesting programs. In this system, TV is not bound to the device: the computer may be used as a TV and vice-versa, while the mobile device may be used as a remote control. The system includes a feature called N-Screen which was designed to help answer the question “What shall we watch?” independently of people location. Imagine a group of friends in different rooms: each one can drag and drop interesting programs to a specific friend in N-screen, or to the whole group, in order to show directly their preferences. When someone receives a new program from a friend in N-Screen, s/he can click on it to see more information about it (basically, it is a drag and drop of movie trailers). Once the N-Screen group has found something interesting to watch together, one of them can drag and drop it to the TV and it will play on the shared TV screen (see Figure 27). The system was designed to be used in conjunction with an out-of-band communications channel (e.g. face to face chat, Skype, or IRC) for the direct negotiations. It was initially developed for tablets and laptops, but runs on any device with a modern Web browser; from smartphones to tablets and desktop PCs. As to the second screen, it is used to choose and control, and then, when ready, play on a large screen. Concluding, users can share recommendations with friends via multiple personal devices in real time. And with the second screen "TV controls watching together-apart becomes a reality" (Aroyo, 2012).

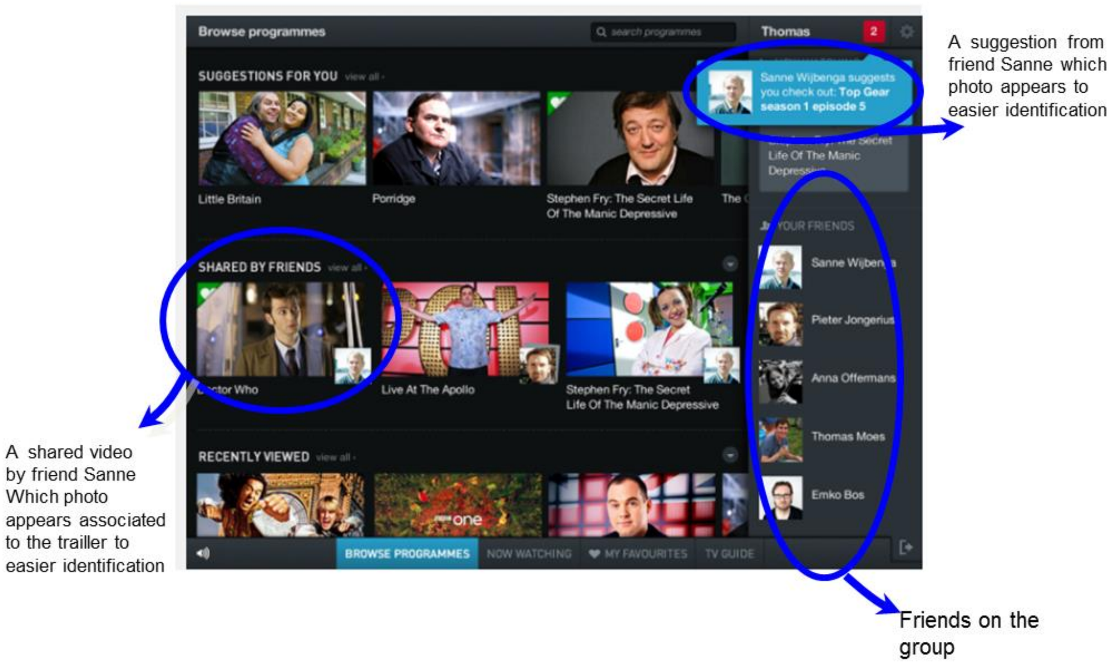


Figure 27. N-screen user interface

Figure adapted with a Figure retrieved from (Aroyo, 2012)

The achieved results have been used to create a set of NoTube showcases, on personalized news from RAI, personalized program guide and advertising from Stoneroos and Thomson, and personalized social TV and second screen sharing from the BBC. Important to mention that the NoTube is, in sum, a recommendation system that allows crossmedia sharing with friends and has several features. N-screen is the one described here, because it is the most close to our research. In fact, it addresses the social side of TV, the importance and the need of being connected and the importance of sharing contents. Applications should be flexible enough in order to accommodate these functionalities. Through N-screen, viewers find movie trailers of interest and they are able to share them with friends in an easy way. However, this share functionality does not include any kind of personalization or adaptation to different cognitive modes, contrary to ours. The eiTV application is second screen. Both mobile and PC devices may be used to interact with the TV set: in order to show the same content that is being watched from the TV; show, previously generated, web contents related to what is being watched from the TV and show the video that was used to generate the web content that is being watched from the TV.

In the era of the second screen, the American channel ABC has developed an iPad application, called ‘My Generation Sync app for iPad’, for its show ‘My Generation’. The application, available for download on the web, installs a new app in the iPad. From there, the user may activate the synchronization mode and then freely interact directly with the TV program. The user may vote, answer quizzes and get real time results, comment the TV content, consult detailed information about the characters, go behind the scenes and discover details about the show, etc (see Figure 28). It is one of the best applications of its kind and as stated by Guérin (2010), the slogan could not be more explicit: “Change the way you watch TV”. It was advertised as an innovative application: one screen in your hands, one screen on the wall[9], and brings to TV watching the benefits of a second screen, to free the TV screen of extraneous info, while providing more control to the viewers, as also explored in research projects. In conceptual terms, it is a very well designed system, very friendly and usable. It addresses the social side of TV, the importance and the need of being connected and able to interact with the program as well as the need to know more about certain issues. However, the only way to access the system functionalities is through the use of two different devices simultaneously, which is limited in terms of flexibility. In fact, the viewers may change their cognition

[9] More information available at: http://www.youtube.com/watch?v=ZY6oJR38OoI

mode and prefer to see the extra information only through one device. The system could be more flexible to accommodate user preferences allowing both options: the use of a second screen or not, as it happens with our application.

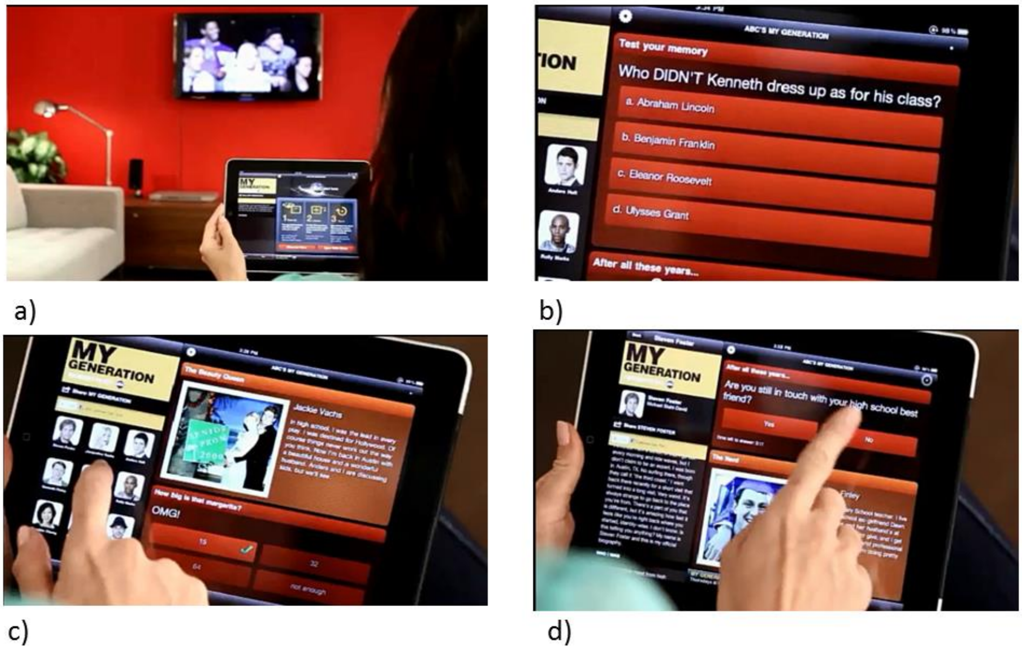


Figure 28. My Generation Sync app for iPad Interface

a) Synchronizing iPad with TV; b) Answering quizzes; c) Knowing more about characters life; d) Answering questions about the TV program. Adapted with Figures captures from (abc, 2010)

2.4.5. Discussion

Some of the presented related works allow access to versions of the same TV or Web content (not additional and extra information) from different devices, in ways related to the TV content being watched, but with limited or too much focus on the personalization. In some projects, the contextualization failed as well as the perception of the application as a whole unit, thus compromising viewers' engagement with the application and their possibility to take advantage of all the implemented functionalities. Other systems were not prepared to accommodate changes in viewers' cognition modes and others did not provide viewers with the possibility to save the additional information for later use.

In all studies, however, the need for extra information, personalized and contextualized, was addressed, thus contributing to understand some of the factors that have to be taken into account when designing crossmedia video based applications.

We believe that the challenge should be to go further in other aspects as we have done with the eiTV application: where we allow the access to related information that complements what is being watched, taking into account user preferences and the cognitive and affective aspects that influence user experiences in a variety of crossmedia scenarios. In our approach, viewers may select, from a video, general information and specific topics of interest in order to generate a personalized web content with extra related multimedia information. This web content is prepared to be viewed at any time, through TV, PC or mobile phones, assuring the contextualization and continuity amongst these media and devices, and taking the best out of each medium, device and context of use. Viewers may also search, edit and share the generated web content with their social network contacts. As to the devices, instead of just allowing the same interaction, each one contributes with what it does best. The devices may also be used in a complementary way, synchronized, as for example watching the video on iTV or mobile phone while the generated web content is presented on the PC. More than a high-tech solution or service, the main concern was the focus on the identified conceptual questions that will be further detailed in chapter 3.

2.5. Summary

This chapter provided an overview on issues that were grouped in four main categories, namely: media, devices and Internet; crossmedia; types of learning and related work.

The media, devices and internet section explored the analysis of the characteristics, evolution, trends, adoption and use patterns associated to TV, PC, mobile devices, Internet and convergence. Recent reports and studies addressing different dimensions provided us with statistical data that allowed understanding the real scenario in different parts of the world.

The crossmedia section presents the motivations that are behind the use of this type of crossmedia applications, presents the different approaches in what refers to the definition of crossmedia, namely the use of other terminology with the same meaning and discusses the main advantages and challenges that are associated to the use of crossmedia applications and systems.

The supporting learning section presents an overview on the different types of learning with a special focus on formal, non-formal and informal learning.

The related work section was organized into four sub-sections: exploring the access to information and socialization through iTV where a brief historical perspective about iTV was presented, describing systems mainly based in TV and Web, crossmedia systems and second screen systems. As a result from the analysis of existing related works it becomes noticeable that, although very useful, varied and extensive, there is space for further developments. In fact, some important dimensions were not fully addressed. In particular, when observing systems more similar to the eiTV, those that are crossmedia video-based, it was possible to identify the more common flaws which were in terms of flexibility, contextualization, affective dimension and adaptation to different cognitive modes.

"*Opportunities for synergy and serendipity do occur, but one has to be flexible enough to recognize them and take advantage of them*"

Ronald T. Azuma

3. Conceptual Framework

This chapter describes the conceptual framework found relevant for the design of crossmedia interactive services involving video, as the eiTV application, using an iTV design framework (Prata *et al*., 2006) and addressing the crossmedia design challenges with a special focus on TV, PC/web and mobile devices. The conceptual crossmedia framework proposed follows a User Centered Design (UCD) approach and its main stages, namely: analysis and requirements gathering, design, prototyping and evaluation which are briefly explained at the beginning of the chapter.

3.1. User Centered Design in HCI and Crossmedia

The Human Computer Interaction (HCI) research area is a vast multidisciplinary area that is based on the study of the way people and technologies influence and interact with each other, as well as on the principles around it. In practical terms, it involves the study, planning, and design of the interaction between people (users) and computers. In sum, the HCI main goal is to improve the interactions between users and computers by making computers more usable and receptive to the user's needs (Dix *et al*., 2004) through central components as, for instance, the design methodologies which are available to provide designers with mental frameworks and practical procedures to guide them through particular systems design process. User Centered Design (UCD) methodologies are a particular type of methodologies where users needs, wishes and expectations are taken into account. Considering that systems are developed for users and so, it is a rule of thumb that systems are supposed to adapt to users and not the opposite, this methodology becomes very important in order to respond to the users' needs and adapt the design to their circumstances (Norman, 2002). This methodology is described in the next sections.

3.1.1. Involving the User in the Design Process

The official definition of UCD comes from the International Organization for Standardization (ISO), in concrete from the 13407:1999 standard: "*Human-centered design is an approach to interactive systems development that focuses specifically on making systems usable. It is a multi-disciplinary activity which incorporated human factors and ergonomics knowledge and techniques*". To follow a UCD approach in order to design an application implies to actively involve users in all the development phases, meaning that they should be seen as partners since the beginning until the end of the development and evaluation process. It also implies designing for usability which is an approach that puts the user, instead of the system, at the center of the process when developing software (Nielsen, 2012). Many benefits result from such an approach, namely, "*increased productivity, enhanced quality of work, reduction in support and training costs and improved user satisfaction*" (ISO13407, 1999). As clearly referred to in the standard "*it complements existing design approaches and methods*" thus meaning that it is not supposed to be used alone but, instead, complements other approaches and techniques. In fact, as stated by (Sá, 2007) available literature does not include specific UCD methodologies for mobile devices and we could not find specific UCD methodologies for iTV and crossmedia applications as well. After a considerable review of relevant literature on emerging crossmedia HCI research methods, it was possible to conclude that new methodological approaches and techniques are necessary. In fact, in spite of its valuable contribution, none of the studied UCD methodologies, namely, Task-Centered Design, Scenario-Based Design and Contextual Design, devotes particular attention to variables as volatile contexts, ubiquity, transitions between usage settings, changes in cognition modes and transitions between devices. This does not mean that UCD is not needed, on the contrary. UCD methodologies design approaches have been successfully used on the design of many generic interactive applications and, in spite of not addressing mobile, iTV and crossmedia scenarios and systems in particular, they include several procedures and techniques to support UCD main stages (analysis and data gathering, design, prototyping and evaluation), that are universal and more general. Thus being, these universal procedures should be used and, ideally, complemented with specific ones, depending on the specific scenario and system, a situation that is in accordance with the ISO standard.

3.1.2. User Centered Design Main Stages

In the UCD design methodologies the following main stages are common:

Analysis and Data Gathering: refers to the first stage, where requirements and data is gathered and analyzed. Thus, it is sometimes referred to as Analysis or Analysis and Data Gathering stage. The identification and study of possible scenarios is an important part of this stage, in order to identify important factors that need to be considered in the design phase, to produce efficient applications. A first step towards a good application design is also the identification of functional and non-functional requirements. Functional requirements define capabilities and functions that a system must be able to perform successfully, behaviors or, in short, what the application should do. Non functional requirements refer to other properties, specific criteria that can be used to judge the operation of an application, rather than specific functions or behaviors, in short, how the application should be, its application qualities (Wiegers, 2003) including usability aspects.

Design: after gathering and analyzing all the needed information, the data is modeled and consolidated in order to create work models that will allow detecting existing problems and generate ideas, creating a vision for a possible system. That vision (which in our work we refer to as conceptual model) will then serve as the basis for structuring and modeling the UI application, often through sketches composed by paper and post-its and integrated in story boards that represent their articulation, meaning non-functional solutions. These are often incorporated in the low-fidelity prototypes that are used during the evaluation sessions, in order to evaluate the viability and usability of the sketched UIs, normally in a simulated usage scenario. In some cases, low-fidelity prototypes are considered as part of the Prototyping stage instead of part of the Design phase.

Prototyping: as stated in (ISO13407, 1999) a "*prototype is a representation of all or part of a product or system that, although limited in some way, can be used for evaluation*". Prototypes are an essential tool considering that they allow designers to test their ideas and concepts with end users before completing the final product (Hanington, 2006; Mayhew, 1999). Different types of prototypes may be used: **Low-fidelity prototypes**, non-functional UIs that are many times simple hand designed sketches on paper cards or post-its, put together with glue (Holtzblatt *et al*., 2005; Virzi *et al.,* 2006), in order to simulate a real system while evaluating ideas about interfaces, functionalities, features and detecting its flaws at very early stages of design (Rosenberg, 2006). These prototypes are a crucial tool for designers considering that they provide valuable feedback with low cost investment (Connelly *et al*., 2005; Virzi *et al*., 2006). Associated to low fidelity prototypes appears the technique of Wizard of Oz where the designer acts like the system, changing sketches and screens according to users actions (Kelley, 1984) in (Sá, 2009); **Mid-fidelity** prototypes: often used to describe prototypes which are somewhere in-between low and high-fidelity (McCurdy *et al*., 2006); **Mixed-fidelity** prototypes: is a recent concept and refers to a prototype which is high fidelity in some dimensions and low fidelity in others, and **High Fidelity** Prototypes: interactive prototypes with realistic input and output interfaces, they refer to a better Graphics model of a product (Yasar, 2007) and are generally composed by functional software components that can be experimented on the targeted platforms (Sá, 2007). They are the most adequate prototypes in the last phases, when the intention is to validate a realistic product in a realistic scenario with future viewers and before implementing the final product.

Concluding, and independently of the device being used, prototyping techniques that support the construction and evaluation of prototypes in realistic scenarios are needed. In general terms, all components (device prototype and UI prototype) must be as faithful to the original as possible. However, in early stages of development, in order to test interfaces design and usability, low fidelity prototypes are recommended. They represent a low investment and help detecting a considerable amount of usability problems.

Evaluation: refers to the evaluation of low or high fidelity prototypes, which will evolve from version to version as the results of several evaluation trials until reaching a good solution. Sometimes Evaluation appears associated to Prototyping as a single stage (ISO13407, 1999; Pratt & Nunes, 2012).

According to (Obrist & Knoch, 2011), the user experience (UX) evaluation methods and measures relevant, when ubiquitous TV is involved are: physiological data, data mining, log files, observation, case studies, lab experiments/evaluation sessions, experience sampling method, probes, diaries, interviews, surveys/questionnaires and focus groups. The combination of methods to use depends on each specific case.

3.2. Crossmedia Analysis and Design

A successful application provides the best match between technology and the function it supports, along with flexibility in their combination (Prata & Chambel, 2012). This raises a challenge when designing effective and consistent applications across media due to the number of different devices, with different characteristics, contexts of use, functionalities and support for different cognitive modes which implies a higher level of difficulty. The crossmedia application as a whole, and each device interface in particular, has to be designed in accordance with these factors. However, a real crossmedia design should go beyond the design principles and characteristics of each device individually in order to create real interactive experiences (Pasman, 2011). Ideally, "*Smooth, meaningful and logical transitions from one platform to another should take place, stretching and blurring their respective boundaries*" (Pasman, 2011). Thus, an effective design takes cognitive and affective aspects into account in the use of, and interaction with, different media. We explored the design of crossmedia environments taking into account several dimensions that will be explained and integrated along this chapter and the concerns specific for each device, as presented next.

3.2.1. Media and Cognition

Norman's view (Norman, 1993) defines two fundamental cognitive modes that are relevant to understand our relation with media: experiential and reflective.

The **experiential mode** of cognition allows us to perceive and react to events efficiently and without effort. It is the mode of the expert behavior, the mode of perception, entertainment, motivation and inspiration. In spite of being the key component of efficient performance, we need more if the goal is to create knowledge and human understanding. Reflection becomes fundamental in order to achieve and consolidate new ideas and concepts.

The **reflective mode** of cognition is the one "of comparison and contrast, of thought, of decision making", of reasoning and contemplation.

One may alternate between these two modes, depending on several kinds of internal and external factors, and both are important in human cognition, but require different technological support.

Several communicational *media* may transmit the same information. However, the medium is not neutral. Due to its characteristics, it affects the way we interpret and use the message and the impact it has on us (Norman, 1993; McLuhan, 1964). TV is usually watched in the experiential mode, commonly associated with entertainment, in a more relaxed and passive way, and it is easy to use since it does not require previous practice or much mental effort. However, when properly constructed and augmented, TV may turn into a powerful tool for reflection, inducing and supporting a more active attitude without forcing a change in its experiential nature. In fact, when users are allowed to choose what to see, controlling the speed of the contents; when they easily: go back and forth, stop, make annotations; and when they are allowed to compare and to relate what they are watching with other contents, a rich audio-visual technology able to afford reflection naturally arises from traditional TV (Norman, 1993; Chambel & Guimarães, 2002). Books induce a more active and reflective attitude, important in learning processes; while telephones were traditionally used for communication, greatly empowered by their current mobility and multimedia support. Networked multimedia computers have somehow the ability to accommodate these properties, but in limited ways depending on the devices being used.

A successful integration, in a crossmedia environment, should have each medium and device support what it is most suited for in each context of use, augmenting and complementing their capabilities in a flexible combination.

An entertainment medium like TV can be extended to support or create opportunities for reflective cognition without forcing a change in its experiential nature. For e.g., if the user is capable to easily select some program topics, without disturbing the TV viewing experience, for further reading on a PC, or by giving access to related short information to be explored right away. Thus and considering that there are several types of communication styles and tools, it is important to be able to identify which solutions work best in a particular context, based on the affordances of the different devices used in a crossmedia environment. In sum, video-based crossmedia applications should be designed to allow users to watch video in its natural inherent experiential mode, but also support reflection, allowing to control what and how to watch, create related web contents adaptable to different cognitive modes, and link topics within the video with the video-based related materials.

Along with the different cognitive modes, there are many types of learning (e.g. formal, non-formal and informal. See section 2.3. for more details) and many factors which have proven to contribute to the improvement of the learning process, as the use of multimedia contents, interactivity and communication tools. Considering that there are several types of communication styles and tools, it is important to be able to identify which solution works best in a particular environment as explored next.

3.2.2. Cognitive Theory of Multimedia Learning

The cognitive theory of multimedia learning proposed by Mayer (2001), where the use of audio-visual information in different perspectives is studied, especially in the learning perspective, is helpful in the context of crossmedia learning (formal, non-formal and informal learning contexts). In fact, this thesis main focus is on video-based informal learning crossmedia environments, and these are often multimedia. Mayers' theory (Mayer, 2001) is based on human information processing and cognition theories and three fundamental assumptions:

Dual Coding Assumption (Paivio, 1991): which defends that visual and auditory information are processed in separate, in terms of working memory, where they are selected and organized. After that process, both types of information may be correlated and integrated with other information present in long-term memory;

Limited Capacity Assumption: meaning that humans are limited in terms of the information amount that they are able to process simultaneously;

Active Processing Assumption: humans' usually process arriving information cognitively in an active way. In fact, they select relevant information and construct coherent mental representations, that is to say, they are able to integrate the selected information with already stored one.

Based on its own research, and on the Dual Code Theory from Paivio (1991), Mayer (2001) proposed six design principles that may help to reduce the cognitive load and promote learning, when the idea is to complement or reinforce information through media integration:

1) **Split-Attention Principle**: states that it is easier to learn when the instructional material does not require splitting the attention between many sources of equally referring information (both visual or verbal);
2) **Modality Principle**: states that it is easier to learn verbal information when presented as audio narration, instead of visually as text on the screen, either for simultaneous or sequential presentations;
3) **Redundancy Principle**: states that is easier to learn from complementing sources as for e.g. animation and narration, video and narration (provided they do not cause split attention, e.g. animation, narration and text simultaneously);
4) **Spatial Contiguity Principle**: states that it is easier to learn when the on-screen text and visual materials are physically integrated;
5) **Temporal Contiguity Principle**: states that it is easier to learn when verbal and visual materials are temporally synchronized;
6) **Coherence Principle**: states that it is easier to learn when superfluous materials (sounds, words, etc.) are excluded from multimedia explanations.

The guidelines by Mayer (2001) address media integration but need to be complemented for video-based crossmedia applications, in order to accommodate its increased complexity, especially due to the extra challenges video brings to the scenario (Chambel & Guimarães, 2002), and should address the delivery of: **control**, to be able to 'navigate' the videos; **consistency** and **coherence**, to reduce cognitive load; **structure**, context and searching facilities for orientation purposes, e.g. use video web search, excerpts of video for **contextualization**, etc; **familiarity**, for example through the adoption of metaphors, like television and books; and **continuity**, for a sense of unity and coherence.

3.2.3. Supporting Crossmedia Interaction

This section addresses the main aspects, which may also designated as dimensions, that need to be considered in order to support crossmedia interaction as presented next.

3.2.3.1. Crossmedia Interaction Design Challenges

Users that work with several devices want a continuous experience when interacting across them (Pierce & Nichols, 2008), they expect to reuse their interaction knowledge from previous experience, when they switch medium (Florins & Vanderdonckt, 2004) and, ideally, also expect to use their devices in a more integrated fashion than as a collection of independent devices (Pierce & Nichols, 2008). However, these authors stated that the experiences provided by devices and applications are far from satisfying those wishes. Thus being, a detailed analysis of the factors that influence a good crossmedia interaction was conducted as follows.

The challenges of crossmedia interaction design were grouped by Segerståhl (2008) into three main areas:

Heterogeneity: when several interaction devices and applications are part of a system, the user technological literacy (theoretical and practical technological skills and knowledge) needs to be higher. Another challenge arises from the differences in terms of the medium and contexts of use, which are determinant in terms of adequacy between the system and its users. User expectations also vary in the presence of each different medium;

Interoperability: this concept, usually referred to as the system interconnectivity, is as relevant as the conceptual architecture - a fundamental tool since it shows how the system works, how each role is supported by each medium, and how functionalities are distributed. Defined as **Composition** by Denis & Karsenty (2004), it is one of the vital focal points in crossmedia design. It controls how applications and devices, within a system, relate to each other. As requirements for crossmedia composition, the focus is to match devices and functionalities. In a system, when each device and its functionality is optimized for a specific use context or situation, the service adaptability may be increased. Adaptability was defined by Denis & Karsenty (2004) as something that is achieved when the composition of a system is appropriate.

Consistency: the system may comprise a distributed design (when the design is spread through different devices) or a concentrate design. It may vary in terms of goals depending on the device being used, may even vary in terms of subject areas across devices. These factors increase the risk of inconsistency in terms of semantics, interaction logic, devices and applications design due to the use of different devices. In spite of the difficulty due to the number of variables involved, consistency needs to be assured in order to provide users with a good mental image of the system and to facilitate interaction. According to Denis & Karsenty (2004), crossmedia consistency, one of the most highlighted principles in multi-device systems usability, refers to perceptual, lexical, syntactical and semantic consistency. **Perceptual** consistency relates to the appearance, structure and order of the information presented (look n' feel). **Lexical** consistency relates with labels and UI objects (symbols and terminology). **Syntactical** consistency refers to having the same operations available on each device to achieve a certain goal (interaction logic). **Semantic** consistency covers, amongst others, division of data and functionality.

In our opinion, it is important to keep in mind that systems and devices cannot, and should not, be completely similar every time. For e.g. a web content needs to be adapted when to be used from a mobile device considering that due to the tactile screen different interaction possibilities are available when compared to the PC screen. In fact, as stated by Segerståhl (2009), heterogeneity of functionality in crossmedia systems may bring added value to their use. However, and according with basic usability principles, we agree that the 'look and feel', the used terminology, symbols and other variables and the interaction logic (which refers to the navigation details and the way certain actions are achieved) should be as consistent as possible across devices in order to facilitate users' perception of the system.

In a crossmedia system, the user activity may be supported by different media and devices that complement and enhance each other. In fact, the user may carry out a task through a sequence of devices (e.g. start watching a video on the TV and interacting with it, move to a laptop and continue its work to explore it along with related information and services, then continue in a smart phone). This migration of tasks should be supported with crossmedia usability and **continuity** concerns, influencing on how well and **smoothly** users' skills and experiences are transferred across the different media or devices, meaning that continuity supports interoperability (Denis & Karsenty, 2004). Thus, in spite of changing medium, a **consistent** interaction (in terms of terminology, graphics, etc) and **contextualization** strategies, created in order to help understand the sequence of events and the relation between them, will improve the usability of the system and help break barriers to the adoption of crossmedia systems (Paternó & Santoro, 2012; Wäljas *et al*., 2010). Following Denis & Karsenty (2004), continuity is supported by consistency, since consistency helps users transferring their skills from one situation of use to another, but is not enough. In order to assure continuity, active interaction strategies are needed in order to help users understand how devices may be connected and used together. Strategies and active techniques as crossmedia referencing are needed. Crossmedia referencing implies that interactive situations on one device suggest connections to other devices within the same system. These strategies help users to distinguish between different use practices and even suggest different devices (Denis & Karsenty, 2004). Thus being, **consistency** and **continuity** across devices are, in the opinion of Antila & Lui (2011), the most important requirements to ensure the inter-usability of a crossmedia system.

The consistent look and feel across media is an important requirement, keeping in mind the goal of having each medium doing what it is most suited for and extending its characteristics (synergic use) (Nielsen, 1989). As such, it is important to understand the devices and their affordances, and how to effectively design for them, in isolation and especially in combination, as addressed in the next sections.

The quality of a crossmedia system interaction cannot be measured only by the quality of its parts. It has to be measured as a whole. Following Segerståhl (2008), there are three essential factors in order to determine the success of an information system: how easily it was adopted, how well it was implemented and the level to which characteristics and functionalities of the system are used. Thus, considering that a crossmedia system is a specific type of information system, these three factors will be applicable. However, it is our belief that, due to the complexity of a crossmedia system, measuring these factors will be a more complex task. In order to help us in what relates to the quality of the interaction design and thus achieving good results through a successful system, important factors should be considered as, for instance, the usability and user experience, as presented in sections 3.2.3.4. and 3.2.3.5., respectively.

3.2.3.2. Crossmedia Devices Redundancy and Synergic Use

There are different degrees of **device redundancy** that illustrate how the roles of devices may be organized within a crossmedia application, system or service. Denis & Karsenty (2004) defined three degrees as presented next:

a) *Redundant devices* means that all devices provide access to the same data and functions;

b) *Complementary* devices share an area of data and functions that is common. It is a specific part of the application that may be accessed from all devices. However, one or more of the involved devices also provide access to data and functions that are only specific of that device and may not be accessed through the other ones;

c) *Exclusive devices* means that each device provides access to different data and functions.

Synergic use, a concept that was previously used by Schilling (2000) with the name of synergistic specificity, means using combinations of media in order to achieve a level of task support higher than it would be possible through the use of each one individually (Segerståhl & Oinas-Kukkonen, 2007). The degree of synergic use of an application, system or service, strongly depends on the device redundancy. Systems high in synergic use may support functionality and user experiences in a way that more modular systems cannot. In fact, there are systems which main functionality relies on improving the components' capability to work with each other. As a consequence, in these systems, separate the components or using them isolated would result in a loss of performance or even in the whole system paralyzing (Wäljas *et al*., 2010). As an example of high degree synergic use, Segerståhl (2009) referred to the Apple iPod product family where mobile devices are dependent on the PC application which is the source of power and content. However, different levels of synergic use degree are available, meaning that some systems are more flexible than others, allowing the use of devices in different combinations and operated independently, in other words, systems with higher functional modularity. Important to mention that these systems, although more modular, may also achieve synergy if used in a way that allows the merge of their components benefits.

Concluding, device redundancy and synergic use are important concepts when describing the configuration of a crossmedia system and may help "explaining some conflicts that occur, when users try to use devices in a system in ways that are not supported by its configuration" (Wäljas *et al*., 2010).

3.2.3.3. Crossmedia User Interfaces

A group of dimensions were identified by Paternò and Santoro (2012) as useful in the design of new crossmedia UI applications and evaluation of existing ones. The most relevant to our work are:

UI Distribution: this dimension analyses if the considered solution is capable to support the distribution of the UI different elements across devices. In this type of distribution there is always (at least) two devices involved at each time, meaning that coordination across the devices is needed and that elements may be duplicated or not.

UI Migration: this dimension analyses if there is **continuity** when users change device within the same application. Users should be able to change the device in use and still accessing the same application, from an adapted UI, and at the interaction state reached with the first device. It is important to note that migratory and distributed UIs are two different concepts: some distributed UIs are able to migrate and some are not, and some migratory UIs are not distributed across multiple devices. Distributed UIs are measured by the number of elements which state may be preserved and transferred from one device to another: UI elements, functions, history, bookmarks, etc. According to Wäljas *et al*. (2010) **continuity** is considered to depend on how well the system supports cross-platform **transitions**, **task migration** and **synchronization**.

UI Granularity: this dimension refers to granularity of the UI that is being manipulated across devices (through distribution or migration). As to the range of values for this dimension, they are:

a) *The entire UI*: the UI is considered as a single item that may be, for e.g., moved/copied between devices;
b) *Groups of UI elements*: structured parts of UI, as for e.g. navigation bars, may be distributed across various devices;
c) *Single UI elements*: single UI elements are distributed across devices. For e.g. a user enters an input through a mobile device and the resulting feedback is shown on a large screen.

Trigger Activation Type: this dimension analyses how the demand for a change in the UI is triggered. Three main options are available:

a) It may be *initiated by the user* (the simplest way) that selects what, when and to which device should be changed. It may also distinguish between push and pull, depending on the triggered migration being from the local device to a remote or vice versa;
b) It may be *automatic* (the more complex). The system acts proactively by activating the changes when it identifies appropriate conditions (e.g. in case of a video watching in a mobile device with low battery and the proximity of a TV set, the system may transfer the video to the TV).
c) *Mixed type of trigger activation:* In this case, the changes are partially automatic and partially triggered by the user. Usually the system starts by suggesting changes to the user that is able to change some parameters.

Timing: this dimension is about the time when a device change should occur in a multi-device configuration. A migration may occur immediately after being triggered (immediate effect), in order to achieve continuity, or may allow the user to specify when the device change should occur (deferred effect). The deferred option is particularly useful when the target device is unavailable. The range of values available include: immediate, deferred and mixed (which happens when immediate and deferred are both possible).

Interaction Modalities Involved: this dimension is responsible for the analysis of the modalities involved in the multi-device UI. Three values are possible, namely:

a) *Mono-modality*: meaning that all the devices involved in the crossmedia access support the same (single) interaction modality;
b) *Trans-modality*: meaning that different devices may support different interaction modalities, but each device supports only one interaction modality at a given time;
c) *Multi-modality*: it occurs when the multi-device interface simultaneously supports two or more interaction modalities in, at least, one of the devices involved.

Concluding, the group of dimensions found more relevant to support, and evaluate, the design of new video-based crossmedia UI applications were: UI distribution, UI migration; UI granularity; Trigger Activation Type; Timing and Interaction Modalities Involved.

3.2.3.4. Usability

One of the best known definitions of usability was proposed by Nielsen, who states that usability is about learnability, efficiency, memorability, errors and satisfaction (Nielsen, 1994a). However, ISO 9241-11 (1998) and ISO 13407 (1999) are two important standards related to usability: the first one provides the definition and the second one provides the guidance for designing usability. Following the ISO 9241-11 standard, usability is defined as "*the extent to which a product can be used by specified users to achieve specified goals with **effectiveness**, **efficiency** and **satisfaction** in a specified context of use*". This definition is becoming the main reference of usability. However, following Preece, Rogers and Sharp (Preece *et al.*, 2002), usability may be defined as the measure related to the system ease of use or system understanding, but not only. It is also related to the system security, efficiency and users attitudes in relation to the system. The users' attitudes in relation to the system tend to vary according to their technological literacy (their theoretical and practical technological skills). Even the most technological literate have their attention spread due to the amount of available technologies and devices, meaning that the population level of technological literacy varies significantly. With the appearance of crossmedia systems, usability concerns increased, as well as the amount of different interfaces and new variables, as the need to assure continuity, coherence and **contextualization** across devices presenting the same system.

In what relates to the usability guidance provided by ISO 13407, it is important to mention that a study conducted by Jokela *et al*. (2003) states that this standard, at a general level, provides good and relevant guidance to User Centered Design (UCD) but, alone, "is not adequate guidance for using the standard definition of usability in a development project". On the study they propose some enhancements as for e.g. the need to "clearly define all the key terms" and be consistent when using them and a more accurate "description of typical features of the process" in order to achieve valid outcomes.

Denis & Karsenty (2004) have proposed a conceptual framework of inter-usability or, in other words, crossmedia usability. The framework proposes design principles addressing crossmedia consistency (see section 3.2.3.1.) and transparency and adaptability (both explained next). Their main focus was on knowledge (in what refers to the system capacity to follow the user activities across devices) and task continuity (in what refers to the system capability to recover "the state of operation after a user's transition from one device to another" (Wäljas *et al*., 2010).

Transparency is needed in order to allow users to understand the system. Thus, when systems have different degrees of redundancy and heterogeneity, it is important to explain their structure to users. That is why the role of help and manuals is important (Denis & Karsenty, 2004). The importance of this kind of transparency depends on the users' technological literacy. For experts, it is easier to understand the potential and limitations of distinct technologies, while for users with lower technological literacy this may be confusing. In spite of being more used to new technologies (for e.g. accessing the web and using different kinds of mobile devices), users still lack knowledge about practices to combine them (Segerståhl, 2009). This is why transparency should concentrate in explaining combinatorial use practices that users may use and integrate into their main activities.

Adaptability which as stated by (Denis & Karsenty, 2004) is a “two-fold principle”. In fact, the system is supposed to help users learn and use all its components in various situations of use. Simultaneously, it refers to the system capability to adapt both to user’s environment and device characteristics. The main goal is to offer relevant information to the current situation. In sum, adaptability has a more broad definition when referring to crossmedia systems meaning that, contrary to other systems, more devices are involved. Thus, to promote the use of devices is not the only goal, instead, the goal is to promote and support the use of different devices in different contexts of use.

In general, an important concept that appears related with HCI and usability is **plasticity.** Plasticity is the ability of UIs to adapt to a context of use (which includes user, platform and environment) while keeping the quality of use (Serna *et al*., 2010). From their research, Serna *et al*. (2010) concluded that usability has been widely studied in interactive systems however not including plasticity concepts. Plasticity is particularly important when in the presence of crossmedia systems where the UIs need to adapt to different contexts of use. From their work, it was possible to see that they needed a long way, in terms of iterations, in order to adapt a PC UI to iPhone. They concluded that both UIs should be simultaneously changed in order to keep the application ‘look and feel’. Concluding, plasticity is a very important concept that needs to be considered in the design of crossmedia contents and, in order to improve efficiency, one should only compare UIs in different contexts after being sure that they are optimal designed (in spite of being aware that there is no unique good design solution) (Serna *et al*., 2010). In spite of the different names, adaptability and plasticity are sometimes used with the same meaning, as it was in this thesis.

Flexibility is the capacity of the system do adapt to different devices, users needs, contexts of use, etc. Although In spite similar to adaptability, it is a broader dimension.

3.2.3.5. User Experience

User Experience (UX) is a concept of much debate and in the opinion of some, “a fuzzy term” (Keinänen, 2011; Wäljas *et al*., 2010). UX, which incorporates several characteristics and dimensions, defined in many different ways in the field of human-computer interaction (HCI), is very relevant since it is considered as an important factor in products success (Jordan, 2000; McCarthy & Wright, 2004; Pierce & Nichols, 2008; Roto, 2006; Tullis, & William, 2008; Väätäjä & Roto, 2010). According to Roto (2006), “*it is basically to fill the gap between a usable and engaging product*” and to Segerståhl (2008), there are many views of the definition of UX. What seems to be common to these views is that UX is characterized as a process that: is influenced by different backgrounds, such as previous experience, social and cultural factors, contexts of use, etc; is analyzed in several dimensions, such as emotional reactions and cognitive processes; and contributes to **different cognitive effects**, such as **emotion**, **learning**, or **acceptance**. As such, the concept of UX extends the usability perspective towards emotional aspects of system quality. In fact, the satisfaction in UX may come from other factors other than the system usability. Previous research showed that in an experiment where different interfaces were tested, the more usable was not the preferred one and that good UX can make people forgive certain usability problems (Pasman, 2011), while bad usability can contribute much to a bad UX. As stated by Hassenzahl & Tractinsky (2006), usability leads to satisfaction by eliminating usability problems, but UX is about designing for pleasure in the first place. Thus, the difference between usability and UX is said to be about **emotions**. While good usability means the lack of discomfort, a good UX means “delight the user”. Anyway, usability and UX clearly influence each other (Pasman, 2011).

Interaction is more manageable when a single medium is being used. Different challenges arise if considering crossmedia UX. When multi-task and multi-technology environments are being used, interaction must be designed in order to accommodate these different contexts (Segerståhl, 2008). Goodhue & Thompson (1995) state that the ‘Task-Technology Fit Model’ is based on the belief that information technologies are used only if their functions support (fit) users’ activities. Thus, it is fundamental to correctly identify the contextual needs that justify and characterize the use of different media and how the different media support human activity. As in Segerståhl (2008), "*Task-Technology Fit can only be understood after analyzing the users' side of the story as well. That is, digging into the users' mental representations of the system at hand and understanding their experiential background*."

In a crossmedia environment, the UX may be evaluated through how well it supports the synergic use of each medium and the different kinds of affordances involved (Tullis & William, 2008; Väätäjä & Roto, 2010). And it is important to understand what makes the user pass the current medium boundaries in order to use other media as well.

According to Segerståhl & Oinas-Kukkonen (2007), in a crossmedia context, the UX may be classified as distributed or coherent:

Distributed UX leads to the isolated perception of each medium and thus is one of the biggest barriers to the efficient use and adoption of crossmedia systems;

Coherent UX leads to the perception of a crossmedia system as a whole unity, which may result in users' higher satisfaction. Wäljas *et al*. (2010) investigated the key elements that characterize crossmedia UX and, based on that, identified a framework for crossmedia UX where one of the three central elements presented was, precisely, the perceived service coherence, meaning that the application and its components are perceived as consistent and coherent, that is to say, as part of the same system. Coherence, one of the challenges of crossmedia interaction design identified by Segerståhl (2008), may be achieved through **consistency**.

The other two key elements identified by Wäljas *et al*. (2010), were:

Fit for cross-contextual activities: meaning that the structure of the application across different devices is in accordance with user's real activity, thus conducting to an effective fit for tasks in different contexts;

Flow of interactions and content: meaning that the transitions across devices are experienced as fluid and connected.

Concluding, more complexity arises when in the presence of a crossmedia environment. In fact, to succeed, a crossmedia context UX should be perceived as coherent, should fit for cross-contextual activities and allow a flow of interactions and content.

3.2.3.6. Personalization

Personalization is the ability of a system to be adapted to users preferences (manually or automatically) and is generally regarded as an important component of any system (McBurney *et al*., 2007). This concept is not as broad as adaptability considering that it focus on the adaptation to users preferences while adaptability focus in the adaptation to a whole context of use (including user, platform and environment). Ideally, personalization reduces the number of direct user interactions in order to input data. The role of personalization is to adapt the functionality and behavior of the system in order to make it react in accordance with the user's context, preferences, state and the resources available at any moment. In the case of a crossmedia system, where different devices are used, the context varies a lot (for e.g. when using a mobile device on the move) and, ideally, the system should act as a pervasive system, tracking this changes of context and adapting its behavior when needed with minimal user intervention (McBurney *et al*., 2007).

Many different levels of personalization are possible ranging from simply choose which type of background to use in the laptop, to using a crossmedia system able to detect which type of device is being used and adapt to the context of use and user preferences automatically. Which type of personalization should be adopted depends on each specific situation and varies depending on the system goal, users technological literacy, etc.

Personalization depends on a set of user preferences which may become difficult to capture. In order to do so, McBurney *et al*. (2007) proposed three approaches:

Manual entry of preferences: in this approach, the users manually insert their preferences through a user-friendly interface. The advantage is that the preferences stored are certainly accurate. The disadvantage is that the users may not be available for longer manual inputs. Thus being, one possible way to minimize the problem is to reduce the manual entry of preferences to the minimum, set some values as default and give users the possibility to easily change their preferences anytime.

Use of Stereotypes: in this approach, some stereotypes are identified and created based on the set of user preferences identified for that specific stereotype. The user only has to choose the correspondent stereotype. In spite of the advantage of being easier for the user, this approach presents several limitations: It is impossible to create stereotypes that cover all possibilities, which means that the user will have to choose the more approximate stereotype (even if not in accordance with some of the predefined preferences); some user preferences change with time; and, for some applications, the user may need to have different stereotypes for the same application.

Automatic Learning of Preferences: this approach implies monitoring users actions and decisions and inferring, from there, changes to their set of preferences. In general, the first set of user preferences is loaded to the system through one of the other two approaches. The advantage is that even with an incomplete load process of preferences, the process will be able to complete it over time. As disadvantages, the process may infer preferences from an ad hoc or short term preferences, thus creating problems to the learning process.

3.2.4. Devices Interfaces Analysis and Design

Interfaces design may be conducted by an important group of general orientation rules and guidelines that are addressed in the HCI research field (Dix *et al*., 2004; Nielsen, 1993; Preece *et al*., 2002; Shneiderman, 1997). However, considering that to design crossmedia applications, interfaces for different devices need to be developed, a detailed study on each device characteristics, challenges, methodologies, design guidelines and possible prototyping techniques was also conducted and is presented in each device specific sections. As to the general methodology, the UCD, and its main stages (analysis and data gathering, design, prototyping and evaluation), was followed to all devices. However, considering that developing for different devices requires different approaches, and in some cases, specific frameworks, in each device section that information is presented and, where needed an explanation on how it fits into the followed UCD methodology is also presented.

3.2.4.1. Interactive Television Analysis and Design

According to Robertson *et al*. (1996), any attempt to create a taxonomy of devices, or media, is a complex problem since device usage patterns change over time and depend on their combination. The best approach is to study each particular situation, including device characteristics and cognitive and affective aspects associated to its use. Since TV, as a representative and privileged device to watch video, is central in our approach, a more detailed explanation about the questions related to iTV analysis and design, namely, an iTV framework, the motivations and attitudes in watching TV, and a review of devices properties that influence crossmedia design options when TV is involved are presented. Note that many of these properties apply to video watching in other devices but are emphasized in this context of TV.

- **iTV Framework**

The more relevant research studies found in the iTV interface design area (Abreu, 2007; Ahonen *et al*., 2008; Eronen, 2004; Kunert *et al*., 2007; Lamont, 2003a; Lee *et al*., 2008; Lekakos *et al*., 2003; Matos, 2004; Prata, 2005) show that there is not an integrated model. Instead, some scattered UI principles, guidelines, heuristics, design patterns, processes, DOPs (Design Oriented Principles), “steps” and “tips” are usually followed. For this reason, we proposed an iTV Design Framework (Prata *et al*., 2006) for the analysis, design and evaluation of iTV applications, taking into account research in iTV interface design and HCI principles, also integrating the mentioned authors UI principles, guidelines, heuristics, design patterns, processes, DOPs, “steps” and “tips” and adopting a UCD approach. The author proposes a model that relies on the following assumptions:

a) iTV is examined from the perspective of the HCI discipline;

b) An iTV project is the result of a traditional TV program augmented with an interactive application;

c) This model is to be used as a framework for designing and evaluating iTV applications and not as a specification of a standard or a strict set of rules. The overall framework allows designers some flexibility.

In order to keep the focus, only what is specific to iTV applications is described, leaving out stages, phases and tasks that may be considered common to the design of other interactive applications. However, the complete framework is presented in Figure 29.

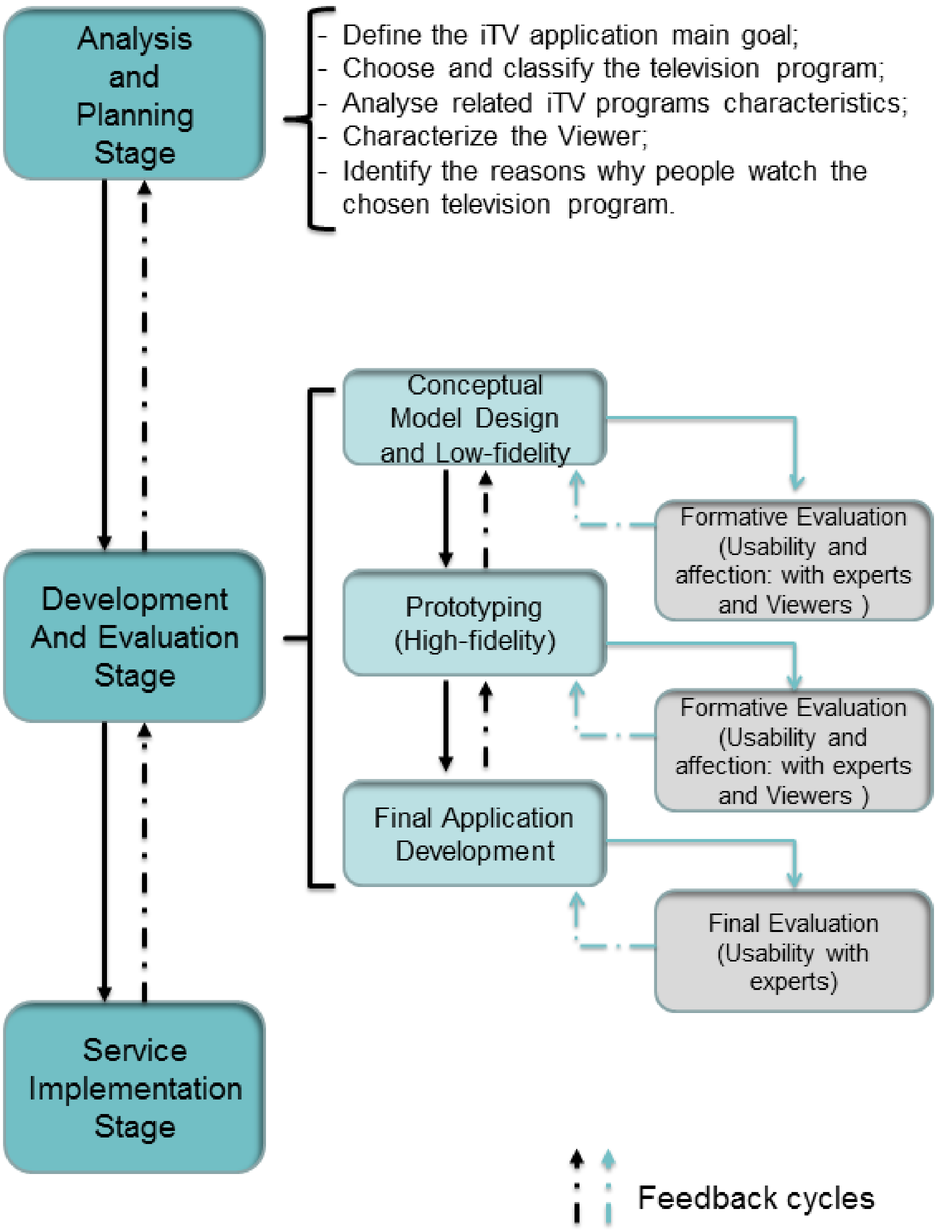


Figure 29. iTV Design Framework

In the proposed iTV framework, the UCD Analysis and Requirements Gathering stage was designated as ‘Analysis and Planning Stage’ and the UCD design stage was designated as ‘Conceptual Model Design and Low-fidelity’. As to iTV design in concrete, a UCD approach should be followed as stated by several authors (Chorianopoulos, 2004; Lamont, 2003b; Nielsen, 1994a; Perera, 2002). As to the Analysis stage, the following specific iTV phases are:

a) *Choose and classify the television program* considering that certain genres are more “compelling for interactivity than others” (Lamont, 2003a) and, based on the chosen genre, design the interaction model in accordance. An example of a questionnaire to choose the program genre is presented in Annex A;

b) *Analyse related iTV programs characteristics* in order to perceive what was already been done and understand how successfully it was;

c) *Characterize the Viewer* in terms of demographic profile (age, sex, socio-economic status); viewing patterns (e.g., social viewing, routines) and technology literacy, which includes computer, set-top box and enhanced television experience. This information will help to make decisions on the following phase and on the development stage. An example of a questionnaire to characterize viewers is presented in Annex B;

d) *Identify the reasons why people watch the chosen television program*. In order to help identify these reasons, one may consider the Uses and Gratification Theory (Livaditi *et al*., 2003) which defends that consumers use media, in order to satisfy certain needs, namely: surveillance, personal identity, integration and social interaction, and diversion (Livaditi *et al*., 2003) as explained next in more detail.

Due to its nature, in terms of position or attitude, iTV usually implies a lean back position and a passive attitude, typically in an experiential cognition mode.

With this information in mind, it is possible to evolve to the next process and start to create a mental image of the system as well as to draw the first sketches.

- **Reasons and Ways of Watching TV**

People have different reasons for watching TV and different ways of doing it. Goals for watching TV depend on the "time and context in which they are watching" it (Taylor & Harper, 2002).

Levels of TV Viewing: previous research has identified **three** levels of TV viewing (Taylor & Harper, 2002) as explained next.

a) **Level one** implies a low degree of viewer engagement and planning, and usually happens when viewers arrive from some sort of activity like work or school. Their main goal is to relax and watch something interesting with the minimum effort (thus, they turn on the TV set and if nothing interesting comes up, they simply keep switching channels;

b) **Level two** implies a medium to high level of viewer engagement. It is normally associated with programs of general interest. The viewers' goal is to watch periodic programs of interest like news and soap operas;

c) **Level three** implies a high level of viewer engagement and also some planning. This type of viewing is normally solitaire, since individual preferences are the motivation. The viewers' goal is to watch a program of high interest to them, and thus they will plan ahead in order not to miss it. This type of viewing is associated with programs of specific interest like documentaries, dramas or current affairs.

Levels of Attention: while watching a certain program, the viewers' **goals** may change, as a result of internal or external factors, like a headache or a phone call. Several studies have identified four possible levels of attention, also dynamic, when watching TV, ranging from watching it as the only activity, and thus with a high level of attention, to using it only as a source of background noise and thus as a form of companionship (Ali & Lamont, 2000).

The Affective Dimension of TV Viewing may be supported by uses and gratifications theory. Previous research (Livaditi *et al*., 2003) states that traditional TV watching may be explained by this theory, which defends that consumers use media in order to satisfy four needs: *surveillance, personal identity, integration and social interaction*, and *diversion*. Surveillance means that the viewer uses media in order to be informed; personal identity refers to the reinforcement of personal values as, for instance, watching a program in order to compare themselves with the characters, or the real actors, from a movie; integration and social interaction is achieved by watching the lifestyle and personal relationships of other people, in order to gain a certain "sense of belonging", and diversion in the sense that people use TV as a means to escape from reality, that is to say, forget about things and just relax, or as "cultural gratification" and simple entertainment (Livaditi *et al*., 2003).

These needs may be categorized as ritualized (needs of entertainment, companionship and escape) and instrumental or cognitive: **Ritualized use**, the predominant in current TV viewing, implies a viewer in a more passive mode and using a medium as diversion and to pass the time; **Instrumental or cognitive use** implies using a medium in order to seek information contents and cognitive involvement and requires a viewer in a more active mode.

Thus, in **designing interactive applications,** we must consider that: Entertainment and communication applications (that cover ritualized needs) will be adopted easier by the mass audience; Informational and transactional applications (that cover instrumental and cognitive needs) should be designed in order to offer entertainment or communication elements as well.

As to communication or social interaction, a research study (Geerts, *et al*., 2008) has shown that ***News, Soap, Quiz*** and ***Sports*** are **Genres** during which participants talk most while watching them and are thus **suitable for synchronous social iTV** systems. As to ***Film***, ***News***, ***Documentaries*** and ***Music*** programs, they are potentially popular **Genres** for **asynchronous social iTV** systems involving less interruption and immediate communication. As to the case of news, the same number of viewers that like to talk while watching is equivalent to the number of viewers that do not like to talk, being this genre an exception. In what relates to the most appropriate devices, documentaries and movies were often mentioned as 'higher quality content' which is preferably viewed on television, contrary to the weather or breaking news, which viewers prefer to watch on their mobile phone. Concluding, genres with more 'plot structure' are preferred to be watched on TV, while genres with less 'plot structure' may be watched on mobile phones.

- **TV and other Devices**

In this section, the focus will be put in comparing TV with PC/Web and mobile phones, since these are the most commonly integrated in crossmedia scenarios based on video.

When compared with the **PC**, the **TV** use: usually implies a broadcast transmission; viewers with the same speed connection; rare technical problems; a safer environment, since hacking is not a risk on TV; expensive contents production; limited interaction via a remote control; limited customization; limited vertical scrolling; only one window at a time; limited interface; implies a more heterogeneous public, wide audience and group interaction, a relaxed and comfortable position, less attention, concentration and instant interactivity, less specific goals, specific modes of interaction, less interactivity; a compelling interface is fundamental, and ease of use is not enough, since entertainment or communication is also needed (Bates, 2003; Chorianopoulos & Spinellis, 2006; Dimitrova *et al*., 2003a; Eronen, 2004; Prata, 2005).

When compared with **TV**, the **Mobile** phones use: implies a simpler and easier interaction (scrolling, navigation through touch, simple images resizing, etc); smaller screen size; high mobility; functionalities not yet available through TV (GPS sensors, MP3 player, etc); a less safer environment since virus are a risk on mobile devices; more technical problems; different speed connections; more attention; more specific goals.

In spite of maintaining some individual characteristics, as devices are converging, some of the mentioned distinguishing characteristics will become more blurred over time.

- **Conceptual Model and Application Architecture**

A conceptual model is a critical concept in the design process. The *system image*, how the software will look like and act, influences how the system is constructed and should be used (Norman, 2002). A mental image or mental model of a system is produced based on previous experiences and through concepts that come out when visualizing the system working (Jonassen & Henning, 1996). When well designed, systems show people what functions they do and how they do them, being capable of participating in the human construction on how the system works (Segerståhl, 2008).

One must start by *identifying the interactive content*. A survey conducted by Livaditi *et al*. (2003) has shown that ritualized needs (needs of entertainment, companionship and escape) “remain the driving force behind TV usage”.

Considering that the **Quality** of interactive products consists of three elements: **utility** (usefulness), **ease of use** (usability), and **enjoyment** (affective quality or satisfaction) (Chorianopoulos & Spinellis, 2006; Lund, 2011), the Interface will have to be designed in accordance. It will also have to be the less intrusive possible in order not to interfere or conflict with the TV viewer experience (Lamont, 2003a). However, it is important to test different levels of interactivity (more and less intrusive of the iTV experience, and more or less informational) in order to find the most adequate solution to each program and audience. Three specific heuristics for iTV proposed by Ali and Bonnici (Ali, 2000; Bonnici, 2003) should conduct the design:

Interference – the level to which the interactive content interferes with the TV content program;

Intrusion – viewers’ capacity to interact with the interactive content while completely involved on the TV program;

Applicability – the level in which the interactive content relates with the TV program content.

Describing the **iTV Application Semantics:** for each design element on the application, some details must be described, namely, the element name, description, properties, actions, appearance, limitations, related elements and examples of use. This type of organization will be very helpful in the construction of the storyboard.

Important to note that all interaction design decisions, to be made during this stage, should be based on specific iTV viewers interface principles and **guidelines**. At the moment of the first prototypes implementation, iTV was a recent area and the majority of guidelines in use were adapted from the web design field and some were even directly applied to iTV. Thus, a study was conducted in order to: test the few existent specific iTV guidelines (at that time) and rethink and adapt web design guidelines with the aim to propose new guidelines specific for iTV design. The existent guidelines concerning text, graphics, background, interactivity and technical options, described in Prata

(2005), were tested through the design and evaluation of some iTV UIs, and allowed to perceive which guidelines helped achieving usable and enjoyable interfaces. As to the results, only the guidelines related to technical options were not adequate due to constant changes in iTV platforms, TV characteristics, etc.

A more recent study allowed the identification of the more relevant guidelines to use in the context of this work (see Annex C). However, these guidelines for iTV are not totally generalized, especially when used in combination, thus requiring a more profound research when crossmedia is the case, as was carried out along this thesis.

Choosing the Layout: main choices for interactive TV and video layout rely on overlay or embedded designs. On the **overlay** design, the video always displays in full-screen mode, so that the interactive content is placed over top of the screen. On the **embedded** design, the video area is reduced so that content is placed around it (Lamont, 2003a). There is no ideal solution and, before choosing the layout, it is important to carefully consider their advantages and disadvantages. For example, an overlay design advantage is the size of the TV window which is the same as regular TV. A disadvantage is that the content on top of the TV window may be distracting and condition legibility, especially when there is a lot of additional information. As to an embedded design, one advantage is that the content will not appear on top of the TV window and thus will not be distracting and condition legibility. A disadvantage is the small size of the video.

When possible, it is advisable to make both options available, adopting full-screen to maintain strong focus on the video without much information and allow smaller video sizes when to split attention with stronger focus on additional info. The guidelines by Mayer (2001), section 3.2.2., complemented with other criteria, in order to accommodate the increased complexity of video, in video-based crossmedia applications, addressing dimensions as **control**, **consistency** and **coherence**, **structure**, **familiarity** and **continuity**, should be used.

3.2.4.2. Web in PC Analysis and Design

On the PC scenario, contrary to what happens with mobile devices, the user is not in a mutational context by nature. The use of web contents through a PC usually implies a specific place considering the size of the device. As to the position or attitude, it is usually a lean forward position that implies an active attitude and a reflexive cognition mode. In this context, the gathering of requirements, in general, is not considered a difficult task, especially if taking into account that from the three devices considered in this thesis, this is the one with more research studies (Prata *et al*., 2006).

With all the gathered information in mind, it is possible to evolve to the next process and start to create a mental image of the system. The Design Stage comprises the following phases:

Conceptual Model which in this particular case implies the design of the navigation diagram, or navigation map, contemplating all hierarchical levels;

Detailed Design which should be schematically presented through a document for each identified hierarchical level. These documents are generic sketches showing how each hierarchical level will look like, in general terms, and helps designing the low fidelity prototypes;

Prototyping (Low Fidelity). As a suggestion of low fidelity prototypes, design for e.g. hand-made sketches or some type of software schematic presentation that may be displayed on the screen. The evaluator will have to act as the system changing the sketches or the slides (Wizard of Oz). Later and after this first evaluation, high fidelity prototypes are recommended;

Storyboards that should be designed based on the evaluation feedback from low fidelity prototypes and presented with high quality. Several types of software tools may be used for the storyboard design. These files will serve as the basis for the implementation of the high fidelity prototypes;

Analysis and Selection of Authoring Tools. Before choosing the authoring tools, two things need to be clear: what is supposed to be done, how demanding will the application be in technical terms and to characterize the development team in terms of skills. This tools analysis and selection will need to be validated right after the storyboard approval and before the implementation of the high fidelity prototypes.

Many design **guidelines**, rules, heuristics, concepts and tips are available for the PC environment being, from time to time, readjusted by the most well-known researchers in the area, when they become obsolete. Important to mention that, nowadays the majority of these guidelines, rules, etc. are relevant to all sort of interactive applications independently of the device being used. However they are presented in this section considering that they were launched for the first time with the PC paradigm in mind.

The following are recommended: in his homepage, Nielsen has a link to 2397 usability guidelines covering practically all usability aspects (Nielsen, 2005). Other important orientations to follow are:

a) Shneiderman *et al*. (2010) 8 rules of gold: 1) Strive for consistency; 2) Enable frequent users to use shortcuts; 3) Offer informative feedback; 4) Design dialog to yield closure; 5) Error prevention and simple error handling; 6) Permit easy reversal of actions; 7) Support internal locus of control and; 8) Reduce short-term memory load.

b) Nielsen (1994c) 10 heuristics: 1) Visibility of system status; 2) Match between system and the real world; 3) User control and freedom; 4) Consistency and standards; 5) Error prevention; 6) Recognition rather than recall; 7) Flexibility and efficiency of use; 8) Aesthetic and minimalist design; 9) Help users recognize, diagnose, and recover from errors; and 10) Help and documentation.

c) Norman (2002) 5 nuclear concepts on usability: 1) Visibility; 2) Affordance; 3) Mapping; 4) Constraints; and 5) Feedback.

Concluding, the design of a web content to be seen through a PC comprises the following phases: conceptual model, detailed design, prototyping, storyboards, and analysis and selection of authoring tools. As to guidelines, rules, heuristics, concepts and tips, the ones available from Nielsen (2005), Shneiderman *et al*. (2010), Nielsen (1994c) and Norman (2002) are recommended.

3.2.4.3. Mobile Devices Analysis and Design

The appearance and evolution of mobile and ubiquitous computing, supported through different and new devices, contributed to a substantial increase of opportunities and challenges associated with the design process for these new devices, and especially in crossmedia contexts. Due to the specific characteristics of mobile devices, namely, their ubiquitous and permanent nature, small dimensions, several interaction modalities, and the multiplicity of possible contexts of use, these devices interfaces are becoming extremely hard to design, but nevertheless very desirable in many contexts (Sá, 2009), and in particular in our application, due to their flexibility, mobility and location awareness.

On mobile scenarios where the use of the mobile device or application is constantly based on mutational contexts, where users may be walking and passing through different places and environments, the gathering of requirements is a difficult task and needs a specific approach. A framework like the one proposed by Sá (2009) can be used. The framework defines three main modular concepts: conceptual scenarios (scenarios composed by a set of variables as location, persona, device, etc); scenario transitions (used to demonstrate that a change occurred from one contextual scenario to another); and scenario variables (locations and settings; movement and posture; workloads, distractions and activities; devices and usages; users and personas).

As to the position or attitude, it is usually a lean forward position that implies an active attitude and a more reflexive cognition mode.

A UCD approach methodology should be followed, extended with specific directions like those proposed by Sá (2009).

Conceptual model: when mobile devices, as for e.g. mobile phones, are being used, it is crucial to be aware of its available functionalities, considering that they will influence the designer choices and thus the conceptual model. Usually, these types of devices allow sending and receiving SMS, MMS, e-mail, browse the internet, take pictures, make videos, use GPS and increasingly different types of sensors and take the best advantage of a large range of specific apps.

Some of the mentioned functionalities support the implementation of **Content and Location Aware Information Access**. In fact, it is possible to use a captured image or video in order to search for related information to what is on the image or video. However, it is also possible to use the captured image or video GPS coordinates, or simply a specific location GPS coordinates, in order to search information related to the place of capture instead of the image and video content. This is the difference between accessing information based on the content and accessing information based on the location. Next, we present a brief explanation of the method behind these engaging possibilities stressing the emergence of several applications that use them. Text based search is the most common in search engines. However, image search is becoming more popular even in search engines due to research on image content-based retrieval. As an automatic process, this can be a complex task-based on semantic analysis of the image and may include as source of information, e.g.: the image content, the audio information and the annotated metadata at the moment of capture. In the literature of the area, several approaches have been proposed in what refers to annotating images with keywords that describe their content. These approaches were classified by Jesus (2009) as: Manual - the user manually attributes keywords to images; Collaborative - several users contribute with annotations to the same images; Annotations with audio - annotations with words which use speech recognition approaches; Annotations with entertainment applications - refers to annotations which are involved in entertaining activities; Semi-automatic - part of the annotation process is automatic and the other part requires the user intervention; Automatic – the whole annotation process is automatic. The truth is that, in spite of all this evolution, the most accurate annotating system is the manual (Jesus, 2009; Shneiderman &, Kang, 2000) in spite of requiring users intervention. Images Automatic annotation is a complex process considering that it is required to extract characteristics of the visual content, or use metadata associated to the camera parameters at the image capture moment (Exif, 2013), and extracting characteristics of the visual content is the hardest task.

Table 1 presents a brief method characterization proposed by Jesus (2009):

Table 1. Annotation Techniques Characteristics

Retrieved from Jesus (2009)

	Characteristics			
Anotation techniques	**Human effort**	**Performance**	**Input**	**Information**
Manual	***High***	***High***	***Text***	***Keywords***
Collaborative	Average	High	Text	Keywords
Audio	Average	Average	Audio	Keywords
Semi-automatic	Average	Average	Images	Visual and contextual characteristics
Entertainment	Low	High	Text	Keywords
Automatic	Low	Low	Images	Visual and contextual characteristics

There are many automatic systems for annotation in spite of being the ones with lower accuracy. The interrogation can be an image captured by a mobile device when the user is doing some activity and needs additional information. That image would be sent to the server in order to be processed and to index information. This strategy has been used in several systems in order to augment the available information at the instant of the picture capture. Some examples are systems to know more about: fishes (Sonobe *et al*., 2004), flowers (Noda *et al*., 2002), plants leaves (Kim *et al*., 2005) and firefly (Yu *et al*., 2004) and they all can search based on a picture shoot at that moment. Another system called IDeixis, proposed by Yeh *et al*. (2005) is capable to search additional information about the place where the picture has been shoot (using GPS coordinates). These different proposals of systems, with mobile devices applications that use image recovery systems, are a clear signal of the relevance that these systems may assume in the development of new applications in the future (as is the case of our eiTV application).

At this moment, the major problem relies on the type of information to extract from the image and how to use it in order to do automatic annotations at the semantic level. The image content is one of the most used information type, but nowadays, the majority of photographic cameras allow audio annotations, recording information related to the moment of capture in the EXIT component of the JPG file, and some have GPS receivers that allow registering the location. It is also expected a change in photographic cameras technology, allowing more and more sensors to store more information when the picture is taken (Jesus, 2009).

Ideally, the manual annotation technique should be made available complementary to the automatic. However, if someone needs to develop an application that works with metadata associated to images, videos, audio, etc, and if no specific technical knowledge is available, the only annotation technique may be the manual. It is a fact that it requires more viewers' effort, but it is also true that it implies a high accuracy and solves the problem.

As to specific mobile devices **guidelines**, the following are recommended:

Gong & Tarasewich (2004) generic guidelines. The author states that half of Shneiderman's "Golden Rules of Interface Design" (Shneiderman *et al*., 2010) apply to mobile devices without changes, namely: enable frequent users to use shortcuts, offer informative feedback, design dialogs to yield closure and support internal locus of control. As to the other four (consistency, reversal of actions, error prevention and simple error handling, reduce short-term memory load) they were modified and increased in order to be used with mobile devices. As additional guidelines the authors suggested: design for multiple and dynamic contexts; design for small devices; design for limited and split attention; design for speed and recovery; design for "top-down" interaction; allow for personalization; design for enjoyment.

Haywood & Reynolds (2008) set of guidelines to design touchscreen solutions for mobile handsets, were organized by the authors in the following categories: screen size; touchscreen responsiveness; navigation and efficiency of use; virtual keypad; icon design; locking mechanism and battery life. More details may be found in Annex D.

The 60 UX guidelines proposed by Keinänen (2011) and 7 guidelines proposed by Weevers (2011), both proposals for designing high-performance mobile user experiences, are presented in Annex D.

Apple (2011) guidelines for SmartPhones, Brewster's (2002) set of guidelines to overcome the limited screen space, Kar *et al*. (2003) guidelines to design Mobile Information and Entertainment Services, Sánchez *et al*. (2005) navigational hints to the construction of mobile web pages and Roto's (2006) attributes that affect UX in mobile browsing are also a recommended reading.

However, it is important to keep in mind that the existent guidelines for mobile devices are not totally generalized, especially when used in combination, thus requiring a more profound research (beyond the scope of this thesis). Due to space constraints only the more recent references were presented in more detail.

3.3. Crossmedia Prototyping

Independently of the device being used, prototyping techniques that support the construction and evaluation of prototypes in realistic scenarios are needed, through low and high fidelity prototypes. However, prototyping crossmedia applications is a hard task. Many variables need to be considered and each device prototype (hardware and UI) has its own accuracies. In fact, frameworks, guidelines, contexts of use, UX, viewers expectations and needs, varies when the device changes. A good approach, independently of the device, is to start by low fidelity prototypes (possibly based on sketches, power point or other software designed interfaces) and after their evaluation, and based on the collected feedback, migrate to the high fidelity prototypes. From our experience we concluded that when video is involved, due to the dynamic nature of the medium, tests through low-fidelity prototypes require special attention. It is important to identify which factors of the system may be efficiently evaluated and which may not. As an example, when in the presence of an interface with the video embedded, details about the video surrounding interface may be evaluated through low-fidelity prototypes. However, in what refers to the video itself, in low-fidelity prototypes viewers are being presented with a hand-made sketch or, possibly, an improved quality image, but none is capable to reproduce the dynamics and the impact created by a real video on viewers.

The crossmedia major challenge, when high fidelity prototypes need to be implemented, is to have different devices with very different characteristics. A possible solution may be an incremental and modular implementation, but without losing the conceptual image of the system as a whole unit. For e.g. if the goal is to develop an application that should be used through 3 different devices, TV, PC and mobile phone: one may start by conceptualizing and test in low fidelity prototypes to the whole application. After collecting the feedback, then improve the interface, functionalities, options, etc and test again. This procedure may be repeated until a good solution is achieved for the whole application in low fidelity. This allows refining the prototypes without too much investment.

In technical terms, and when referring to high fidelity prototypes, two main options are available:

To choose a **software tool** that helps in the migration of software from one device to another, automatically adapting the UI, as the ones proposed by Ghiani *et al*. (2010), Lin & Landay (2008), Meskens *et al*. (2008; 2010) and Richter (2005). In our opinion, this is not the best option considering that: these tools were conceived in the context of specific situations that do not include all the possible media, meaning that for a specific case more than one technique needs to be used, creating integration technical problems; the tools were not yet sufficiently tested; some tools lack a number of features that are crucial and, from their evaluation, it was possible to perceive that the resultant adapted interfaces present some consistency and usability problems. Due to the mentioned usability problems, a study about the improvement of usability when interfaces are automatically migrated was presented by Nichol's *et al*. (2007). However, even with some improvements, and in spite of being a valuable contribution to research, these automatic methods still need the manual help of the developer if pursuing a good quality final application, but they may provide some automation and have the potential to speed the process to some extent.

Manually design and implement all interfaces details using a group of specific programing tools. For e.g. using Action Script, PHP, MYSQL, HTML and CSS Style sheets is one possible combination of tools but there are others. Important is to use a combination of tools that are in accordance with the programmers' skills. Compared to the previous presented option, this one is more time consuming due to the number of variables and situations that need to be addressed. However, from our experience, is less complex and more consistent considering that the developer: does not need to use different methods depending on the devices and media being used in spite of, probably, have to use different software tools and languages; no integration technical problems will occur; usability and other problems will possibly be detected easier considering that the developer is involved in all the stages and decisions. However, as stated, this is our opinion.

3.3.1. Interactive Television Prototyping

In the proposed iTV framework (see Figure 29), through the different techniques available for creating prototypes, the implementation of low fidelity prototypes in preliminary phases of design in order to detect some usability flaws is also recommended. However, in this case where video, a dynamic medium, plays the central role, a high fidelity prototype is highly recommended. In the creation of a high fidelity iTV prototype, and as suggested by Chorianopoulos (2004), some key elements should be considered, namely:

The Hardware platform: a TV set should be used as an output device; a remote control should be used as an input device. A possible solution may be to use a laptop and an infrared receiver (we started by using the IRMAN infrared sensor available at: http://www.intolect.com/). It allows simulating a "typical watch TV environment", that is to say, an environment which includes the viewer, a TV set and a remote control. In order to avoid interference with the TV viewing experience, no other hardware should be visible to the viewer. A schematic representation is presented in Figure 30 and a real scenario of use is presented in Figure 31.

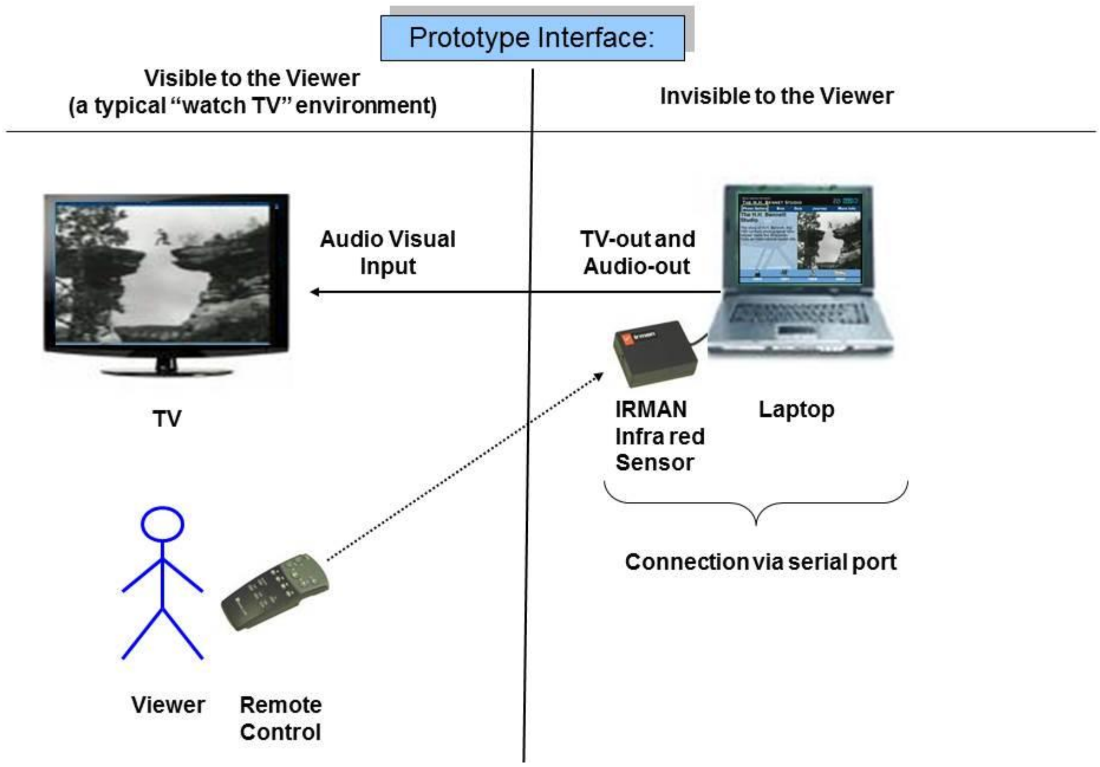


Figure 30. iTV Prototype Hardware Platform

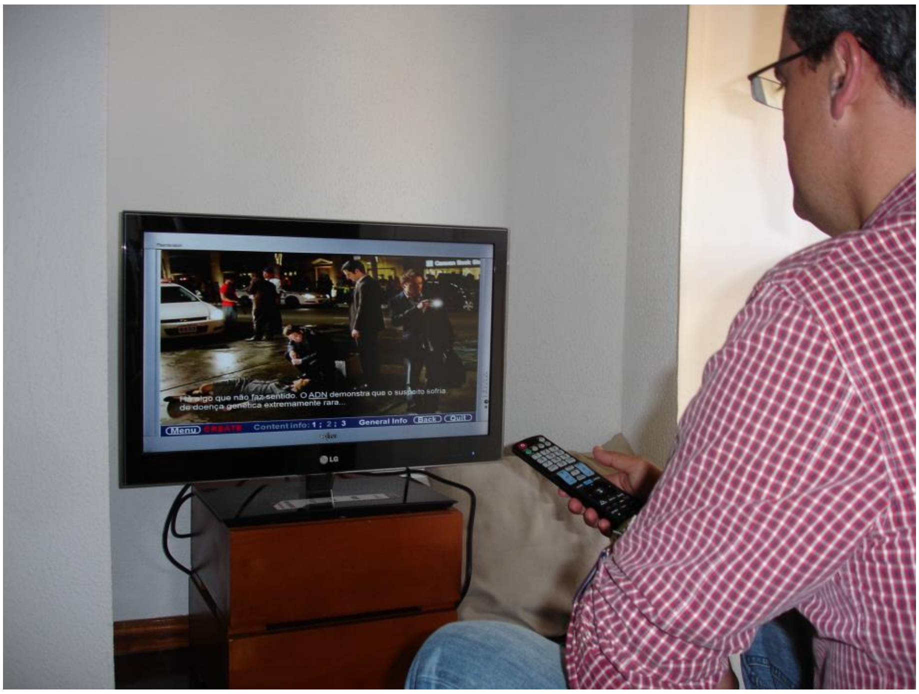


Figure 31. A Viewer using the iTV Prototype

The Software platform: there are usually no iTV authoring tools offering an explicit iTV conceptual model or a TV-based grammar to help the design process. Thus, for the development of iTV applications, traditional programming languages and authoring tools have been often used (Chorianopoulos, 2004) and iTV platforms often made available as exemplified next:

MSTV is a simulator to allow testing TV design in PCs in the MSTV platform;

For the OpenTV platform, the iTV application may be developed by using C programming language or a generic visual authoring environment;

For Multimedia Home Platform (MHP) platform, the iTV application may be developed by using Java programming language or an authoring environment like Alticast MHP;

For the MSTV (Microsoft TV) platform, the iTV application may be developed by using HTML and Javascript. Another solution might be using Microsoft Visual Studio, which has many tools for the design, development, test and deployment of an application (Chorianopoulos, 2004).

Important to remember that, especially when a new type of iTV project is being created, to evaluate it may become a difficult task for the viewers, since they have nothing similar to compare it with. In that case, the development of more than one prototype is recommended.

3.3.2. Mobile Devices and Web in PC Prototyping

Traditional prototyping techniques fail when used in mobiles considering that, as previously discussed, they have different characteristics, features and allow different types of usage. Thus being, attention to a range of details, that are usually disregarded when common fixed devices are prototyped, should be paid. A study conducted by Sá (2009) stated that low-fidelity prototyping for mobile devices should meet the following requirements:

- In spite of not needing to be as faithful as the final application, these prototypes should provide a close resemblance in order to allow viewers understanding the interaction concepts through a realistic usage experience;
- These prototypes should follow the devices characteristics and features but only include the things that are intended to be used in the final application;
- Ideally, these prototypes should be low cost, adjustable and easy to build;
- They should be able to allow designers and users to distinguish between interface design issues from technology related ones.

One of the biggest challenges of mobile applications and prototypes is the small size of the screen. Thus being, all UI elements (images, buttons, etc.), in spite of being hand sketches, should be presented in real size in order to achieve reliable results. However, contrary to what happens with some traditional prototyping techniques, the prototyping of a mobile device also requires the feeling of the hardware. Nevertheless, in order to be low cost, alternative materials may be used in order to mock-up the devices and the UI. Sá (2009), presented several low-fidelity devices that are very similar to the real devices that he was trying to emulate in terms of size, weight and color and which were constructed with different materials as rubber erasers and duck tape, wood, etc. (Figure 32)

Important is to simulate both the device and the UI in order to provide viewers with a richer and more realistic user experience. The prototyping technique proposed by Sá (2009), demonstrated that when mobile devices are involved traditional prototyping techniques are not adequate. In fact, its prototyping proposal was tested with good results.


a) b)

Figure 32. Mobile Devices Low-Fidelity Prototyping

a) A frame with the same dimensions and size than a real Siemens PocketLoox device; b) Real Siemens PocketLoox device.
The frame was built with rubber erasers and duck tape.
Figure retrieved from (Sá, 2009)

Sometimes, after low prototyping or even instead of it, a sort of improved low-fidelity prototyping technique, mixed-fidelity prototyping, may be used. If a real mobile device is available, is possible to design the interfaces in some type of design software (for e.g. power point, photoshop, etc) print them in color and use them over the mobile screen. Considering mobile devices small screens, we believe that using these quality prints will assure a better legibility and quality of the interface elements, namely, the still images captured from the video. The evaluator should use the Wizard of Oz technique. As soon as possible, and after this first evaluation, high fidelity prototypes are recommended considering that the applications are video-based.

As to the web in PC and in terms of low-fidelity prototypes, and contrary to what happens with mobile devices, the use of traditional techniques with UI designed hand sketches and without the need to simulate the physical device is more acceptable. However, and considering that mixed fidelity prototypes are not very expensive in terms of technical implementation, its use is recommended. In fact, the use of graphical files, as for e.g. power point files, or any other good quality, may be used through a PC in order to simulate the real application with good quality and with the evaluator using the Wizard of Oz technique. High-fidelity technical implementation may become relatively easy through the use of specific and intuitive web authoring tools as: Web template generator, Joomla (free), Dreamweaver, flash, etc (Prata & Chambel, 2012).

3.4. Crossmedia Evaluation Framework

The evaluation of a crossmedia application is not an easy task, considering that several devices with specific characteristics are being used and different contexts of use are implied. The affective dimension, UX and Usability fields comprise a considerable number of evaluation methods and measures to choose from. However, there is no perfect combination, each case should be analyzed and the methods and measures adopted in accordance. After a broad research on this subject, a specific combination of evaluation tools, the ones described in this section, is suggested by the author as a possible approach for the evaluation of crossmedia applications where video plays a fundamental role. We believe that a combination of the tools proposed may be a good solution and the framework is adequate considering that it was used to evaluate several prototypes with effectiveness. The evaluation framework is next described.

3.4.1. Viewers Characterization and Selection

Almost all evaluation moments should have the participation of experts and viewers representative of the target population. As to viewers, a relevant dimension is to characterize them in terms of demographic profile (e.g., age, sex, socio-economic status); viewing patterns (e.g., social viewing, routines, preferences), technological literacy, previous experience with the application or type of application being evaluated, and other information depending on what is needed to better characterize the target population, taking into account what is going to be tested. The characterization of the potential users of a new type of application is a fundamental stage in a UCD process. However, and as stated by Eronen (2002), the identification of the target population for an inexistent application is a complex task. A solution relies on observing and interpreting what happens in the use of related applications.

This characterization and viewers selection process is highly recommended considering that richer gathered data usually conduct to richer conclusions. Demographic characterization allows to perceive if the results varies according to sex, age, literacy, etc. Technological literacy allows perceiving if that influences, for instance, the acceptance and adoption of a new application. An example of a questionnaire to characterize viewers is presented in Annex B.

As to the number of users in each group, according to Nielsen (1993), the use of 5-8 users in usability tests represents a good relation between the evaluation costs and the number of usability problems that may be found and it may allow identifying trends in acceptance and satisfaction. However, later usability tests, as for instance the ones from the final evaluation, if with a higher number of users, may lead to conclusions with statistical relevance allowing for more generalizable results.

3.4.2. Formative and Final Evaluation

The evaluation should be both formative and final or summative. The formative evaluation should occur during the whole development process in order to help detecting usability problems in early stages of the design process, and to be able to correct them with low cost. The final evaluation should be conducted after the conclusion of the application with all the functionalities working. Both are explained next. Note that, the evaluation tools referred to in this section will be explained in the next ones.

- **Formative evaluation** should be based on expert's opinion and also viewers (previously characterized and selected) feedback from a UCD perspective.

In a very **early phase** of design, and once the first prototype sketches (low-fidelity prototypes) have been created, conduct an "expert" **usability evaluation** using heuristics and streamlined cognitive walkthroughs[10] (Lamont, 2003a). Also, conduct a viewers usability evaluation through, at least, the following tools: evaluation sessions (possibly through the Wizard of Oz simulation technique) and observation.

For both, experts and viewers, conduct an **affective evaluation** (Chorianopoulos, 2004) with specific tools, in order to measure the affective dimension related with the application use, and to some extent the quality of the User Experience (UX). For more detail, see Figure 33, where the proposed video-based applications evaluation methods and tools are highlighted. Following Chorianopoulos (2004), the affective evaluation process of an iTV application involves the use of some tools, as for instance:

a) SAM: *Self Assessment Manequin* to measure affect*;*

b) HQ scale: *Hedonic Quality Scale* to measure hedonic quality.

For a crossmedia application where video plays a fundamental role, these two tools were considered the most relevant and different enough, in terms of content and approach followed, to justify its use as separate evaluation tools.

In a **later phase** of design, with mid, mixed or high fidelity prototypes, the viewers evaluation in terms of usability, conceptual model, functional solutions and affective evaluation may be carried out with a more detailed set of tools, as presented next.

Usability evaluation:

a) Evaluation sessions (with mid, mixed or high fidelity prototypes), where viewers should follow a specific task-based script (also called scrip of tasks or task list) covering all prototype functionalities. Evaluation sessions should be preceded by a brief explanation of functionalities when needed, and should be recorded;

b) Observation (with the use of a specific grid with the goal to take notes about the prototype functionalities, viewer performance and changes in context). Note that a) and b) should be conducted simultaneously;

c) Questionnaires (may occur right after the evaluation sessions or later, with or without the evaluator presence, via paper or online questionnaires, etc.);

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[10] All the presented evaluation tools will be explained in detail in the next sections

d) Interviews (which may occur during or after evaluation sessions);
e) Focus groups in order to gather new insights (sometimes conducted as interviews).

Affective evaluation:

Through SAM and the HQ scale. However other evaluation tools may also be used.

- The **summative** or **final evaluation** should be based on viewers feedback and it could be conducted in a similar way than the formative evaluation process, but carried out on the final application, with all information and operation implemented.

In sum, the evaluation process can be structured into three different, however complementary, phases as presented in Table 2.

Table 2. Evaluation Process

Phase Number and name	How?
Phase 1 - Characterize and select viewers	Through a questionnaire
Phase 2 - Evaluation sessions	• **To measure Usability**: a) experts: via heuristics and streamlined cognitive walkthroughs (frequently in low fidelity prototypes); b) viewers: task list, observation, grid, recording, questionnaire, interview, focus groups (in all types of prototypes); • **To measure Affection/emotion**: a) experts and viewers: SAM (Self-Assessment Manequin) and HQ scale to measure Hedonic Quality (in all types of prototypes).
Phase 3 - Data compilation and Analysis	May occur with the help of specific software tools

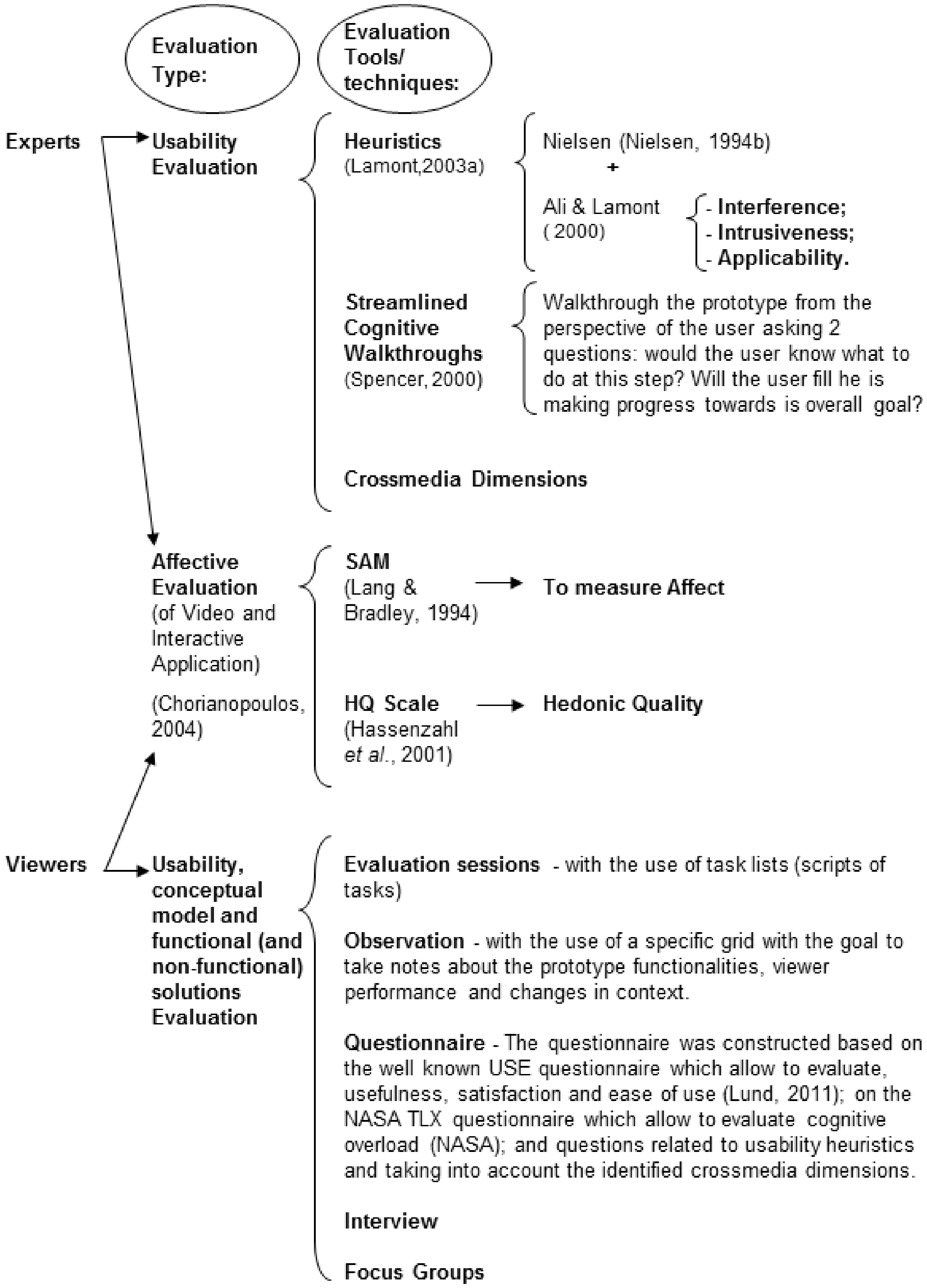


Figure 33. Video-based Crosmedia Applications Evaluation Framework

The mentioned evaluation phases, tools and techniques are explained in the next sections.

3.4.3. Experts Usability Evaluation

Measuring usability is a fundamental part of any interactive application development process and different methods are available. Through the years, many studies and techniques (e.g., heuristics, walkthrough approaches generally used by designers and experts, user testing performed with final users', etc.) have been proposed (Dix *et al*., 2004). Usability inspection methods are usability evaluation methods that involve observation of users by evaluator, or the testing and evaluation of a program by an expert. They provide more quantitative data as tasks can be timed and recorded (Nielsen, 1994b). Next, the 'expert' usability evaluation list of tools is presented.

3.4.3.1. Heuristics

From all the available usability inspection methods, heuristic evaluation has been the most popular one (Nielsen, 1994b). The heuristics goal is to "find the usability problems in the design so that they can be attended to as part of an iterative design process" (Nielsen, 1994b). Thus, this type of evaluation is suited for early use in the usability engineering lifecycle (Nielsen, 1994b).

For broad HCI aspects Nielsen's (1993, 1994b), Shneiderman (1997), Dix et al. (2004) and Preece *et al*. (2002) heuristics are a classic and cover fundamental aspects to take into account and were already addressed in the design section 3.2.. The heuristics proposed by Ali & Lamont (2000) and Bonnici (2003), are still relevant in the context of iTV. Important to mention that Ali & Lamont (2000) heuristics where specifically created for evaluating enhanced television programs. However, considering that they address concepts as interference, intrusiveness and applicability, common to the most used crossmedia devices, and they were used with very good results in our and other prototypes, in order to evaluate their usability interfaces, they are recommended.

Concluding, all the dimensions identified in the crossmedia analysis and design section are relevant and should be considered in the evaluation process complemented with traditional HCI heuristics. Thus, see section 3.2. for the list on the fundamental aspects to take into account in crossmedia design and section 3.2.4. for the list of traditional HCI heuristics complemented with iTV heuristics.

3.4.3.2. Streamlined Cognitive Walkthrough

A Streamlined Cognitive Walkthrough (SCW) is a usability inspection method used to identify usability issues in a piece of software (Spencer, 2000). It focuses on how easy it is for new users to accomplish tasks via the system. This method is based in the notion that users prefer to learn a system by using it to accomplish tasks, rather than, for example, by reading or studying the manuals. There is evidence that this methodology is very successful in identifying usability issues. Thus, these issues may be fixed before submitting the application to the real users evaluation, which becomes more costly (Lamont, 2003b). Thus, walkthrough the prototype from the perspective of the user and ask yourself two questions at each step along the way to completing the overall task: Will the user know what to do at this step? If the user does know what to do at this step, will he feel he is making progress towards the overall goal?

Recording the responses to these questions in the walkthrough will help to find out where usability issues are. This type of evaluation has many advantages, namely, by using one or both of these techniques (heuristic evaluation and SCW), many usability issues will be discovered at this step and can provide feedback into the design to iterate on the prototype. This will help to ensure that the usability testing sessions that involve actual viewers will be more effective and worthwhile (Lamont, 2003a). After a redesign of the interface, it is time for the real viewers testing sessions in order to check the outcome of the iterative design process and to find possible remaining usability problems that were not picked up by the experts usability evaluation (Nielsen, 1994b).

3.4.4. Viewers Usability Evaluation

In what relates to the viewer usability evaluation, the tools are different from the ones used by the ‘experts’ group. As to the number of necessary tools, it depends if a low-fidelity prototype or, instead, a mid, mix, or high fidelity prototype is being evaluated. As to what is being measured, it also depends on the development stage of the prototype. This means that a high fidelity prototype is more likely to allow us to infer about its usability, conceptual model and functional solutions through the same tools. The proposed tools are explained next.

3.4.4.1. Evaluation Sessions

The evaluation should be based on an empirical evaluation via experimentation, meaning that evaluation sessions, in and out of the lab, are usually carried out individually when to evaluate applications that are to be used individually, which is the case of eiTV. This is usually preceded by an explanation of the application basic features which does not need to be individual. Viewers should be advised that they are not being evaluated but the application is, so they have to be really committed with the test. They should be aware that to give us their sincere opinion will be the best way to contribute.

The experimentation should occur in realistic scenarios, and considering that we are proposing a framework for video-based crossmedia applications, very different scenarios will arise. As an example, if an iTV functionality is being tested, then a specific room decorated to look like a typical domestic environment, a living room, should be prepared; if a mobile device functionality is being tested, then it should be indoors and outdoors, in different scenarios (in a living room to simulate the waiting for an appointment, at the end of a bus queue, as a second screen, etc). During the experimentation, viewers should be asked to perform tasks that allow using the more representative application functionalities (for that purpose, a task-based script or task list to follow is needed. The script may be provided to viewers or the evaluator may read it). After finishing the obligatory tasks, viewers should be able to navigate the application freely for a period of time. This will allow evaluators to see which are viewers preferred functionalities considering that they are no longer conditioned by the script.

3.4.4.2. Observation

Observation is a purposeful and selective watching of events as they occur and thus a useful technique for system analysts to use. The main advantage of this type of research method is flexibility, considering that researchers can change their approach as needed and that it measures behavior directly, not reports of behavior or intentions. The main disadvantage is that it cannot be used to study cognitive or affective variables (Sauro & Lewis, 2012) in spite some clues that the evaluator may have from the “thinking aloud” process and by observing viewers reactions to the application.

The experimentation process should be made under direct and indirect observation. Direct observation implies the use of an evaluator that is prepared with a grid constructed based on the script (or task list). Thus, the evaluator will be able to take notes on all the aspects related to each specific task and which, as recommended by Abreu (2007), may be: begin and end time; who concluded the task (viewer or evaluator); viewer reaction (comments/expectations about the task and task understanding); difficulties (directly observed and expressed); application errors (type of errors and viewer reaction); viewers helping needs; evaluator notes, etc. (an example of an observation and evaluation grid may be found at Annex E). However, the evaluator role is not limited to taking notes. They are supposed to conduct viewers along their task lists, solve unexpected technical problems and, in extreme, they may provide some clues in order to help viewers solve specific problems (for e.g. if a viewer is unable to complete a task fundamental to proceed). This type of intervention should be also documented through evaluator notes.

Indirect observation may be achieved through two different procedures: the use of log files and recording the session (video and audio), and both may be used. However, if time is short, the second option may be more indicated.

3.4.4.3. Questionnaires

Questionnaires, also called surveys, provide important information for all kinds of research fields with questions addressing what the evaluator needs to know, and filled by a significant number of individuals (5-8 when usability is the goal).

After the conclusion of the evaluation sessions, or alternatively after the conclusion of each main task (and thus in an interpolate way), a questionnaire should be used. The proposed questionnaire for the eiTV evaluation was constructed based on: the well-known USE questionnaire which allows to evaluate usefulness, satisfaction and ease of use (Lund, 2011); the NASA TLX questionnaire which allows to evaluate cognitive overload (NASA, n.a.) and questions related to usability heuristics and the crossmedia dimensions identified in section 3.2. These questionnaires were used considering that they allow gathering information when referring to the most relevant dimensions of this type of crossmedia applications: usability, cognition and affect. Almost all of the questions were presented with a Likert scale ranging from 1 to 5. With the questionnaire, it is possible to enrich the empirical evaluation[11] and the direct observation. This will give evaluators the possibility to check if the answers given to the questionnaire were in accordance with the reactions, denoting levels of difficulty or satisfaction that were observed in the viewers' while using the application.

Important to mention that, both evaluation sessions and questionnaires should have the participation of viewers representative of the target population which should be categorized in relation to technological literacy, general literacy, age, sex, etc. This implies extra work but it is highly recommended, considering that richer gathered data will lead to richer conclusions.

3.4.4.4. Interviews

An interview is a conversation between two or more people, where questions are asked by the interviewer to elicit facts or statements from the interviewee. An interview is a method for qualitative research, and although it may be classified according to different criteria, the more usual are: structured, semi-structured and unstructured. When structured, each interview is presented with a script with exactly the same questions in the same order. In an unstructured interview, questions can be changed or adapted to meet the respondent's understanding, belief, reactions, problems, etc. Everybody should answer some specific questions and a script is used, but there is a high level of flexibility in relation to the questions that may be adapted to the interviewee when needed. A semi-structured interview is a mixture of the other two, thus with specific and predefined, and also open or new questions.

Semi-structured interviews are more likely to be adequate to this type of crossmedia contexts, considering that many concrete things need to be

[11] Evaluation derived from experience or experiment, experiment and observation rather than theory

validated, and completely new insights are needed and should be expressed, by viewers, without constraints and in a free fashion.

Interviews are useful for several purposes. They help evaluators to clarify and also to validate the obtained results from the observation and questionnaires, allow to complement the information already gathered, help clarifying possible doubts, etc. In sum, they help to consolidate information.

3.4.4.5. Focus Groups

Focus groups is a form of qualitative research in which a group of people is asked about their perceptions, opinions, beliefs, and attitudes towards a product, service, concept, advertisement, idea, or packaging (Henderson & Naomi, 2009). Questions are asked in an interactive group setting where participants are free to talk with other group members. While experimenting prototypes during the evaluation sessions, if not possible to do it individually, viewers should not talk with their colleagues in order not to interfere with their opinion. However, after finishing for example the evaluation sessions, filling the questionnaire (if a questionnaire is being used) and going through the interview (where each viewer will express his own opinion about the application) this type of communication – talking with their colleagues (which we will refer to as 'interaction sessions' or focus groups) - becomes suitable. As stated by French & Springett (2003), it generates a social dialogue in which viewers interact and "mutually externalize rich opinion data, spontaneous insights and retrieved thoughts from previous usage episodes." In spite of not always representative of the traditional environments for watching TV, using mobile devices and PCs environments, these viewers 'interaction sessions' are usually very prolific in providing developers with rich information useful to improve the prototype. Thus, when possible, they should be video recorded for later review.

3.4.5. Affective Evaluation

According to Chorianopoulos (2004), in the affective evaluation process of an iTV project, two different things have to be considered: the TV program and the interactive application. However, he also states that the decomposition of crossmedia video-based applications into two parts (video and interactive application – from each device involved) is merely to help organizing and presenting information, and to ensure, for e.g., that a good video is not influencing the liking of a weak interactive application. This does not mean that the evaluation process should be carried out independently on each part. The ideal situation is to measure the video-based application as a whole. This concern is also true when using other devices interfaces that comprise video and some sort of additional interactive application, which is the case of the crossmedia video-based applications that we are addressing. Thus being, in the affective evaluation of crossmedia video-based applications, the affective evaluation process may be conducted through the use of specific tools that allow measuring: **Affect** - the SAM (*Self-Assessment Manequin)* tool by (Lang & Bradley, 1994) and **Hedonic quality** (task-unrelated qualities or aspects such as novelty or originality) - the HQ scale from Hassenzahl (Hassenzahl *et al*., 2001).

The measuring tools presented were, amongst others, found appropriated for this type of applications (Chorianopoulos, 2004) and are described in the next sections. Due to their preponderant relevance in terms of affective evaluation, for offering a complete overview of important factors and for having a specific structure that would be difficult to integrate in a traditional questionnaire, these two tools, that were retrieved from usability engineering, advertising and consumer research literature, should be used separately. The process and tools are the same for both 'experts' and viewers. SAM and HQ scale tools should be used with low and high fidelity prototypes. In the case of experts, after the usability evaluation (achieved through heuristics and streamlined cognitive walkthroughs), they should be asked to fill these two tools. In the case of viewers, they should fill these tools during the usability evaluation right after the evaluation session in order to capture their immediate feelings.

3.4.5.1. Self-Assessment Manequin:

The *Self-Assessment Manekin* (SAM) proposed by (Lang & Bradley, 1994) is a picture-oriented instrument which measures emotion by directly assessing the pleasure, arousal, and dominance associated in response to an object or event (see Figure 34). It has been used effectively to measure emotional responses in an enormous variety of situations, namely, reactions to pictures, images, sounds, advertisements, painful stimuli and much more. As to the type of target population, SAM has been used, with success, with children, anxiety patients, analogue phobic, psychopaths and other clinical populations.

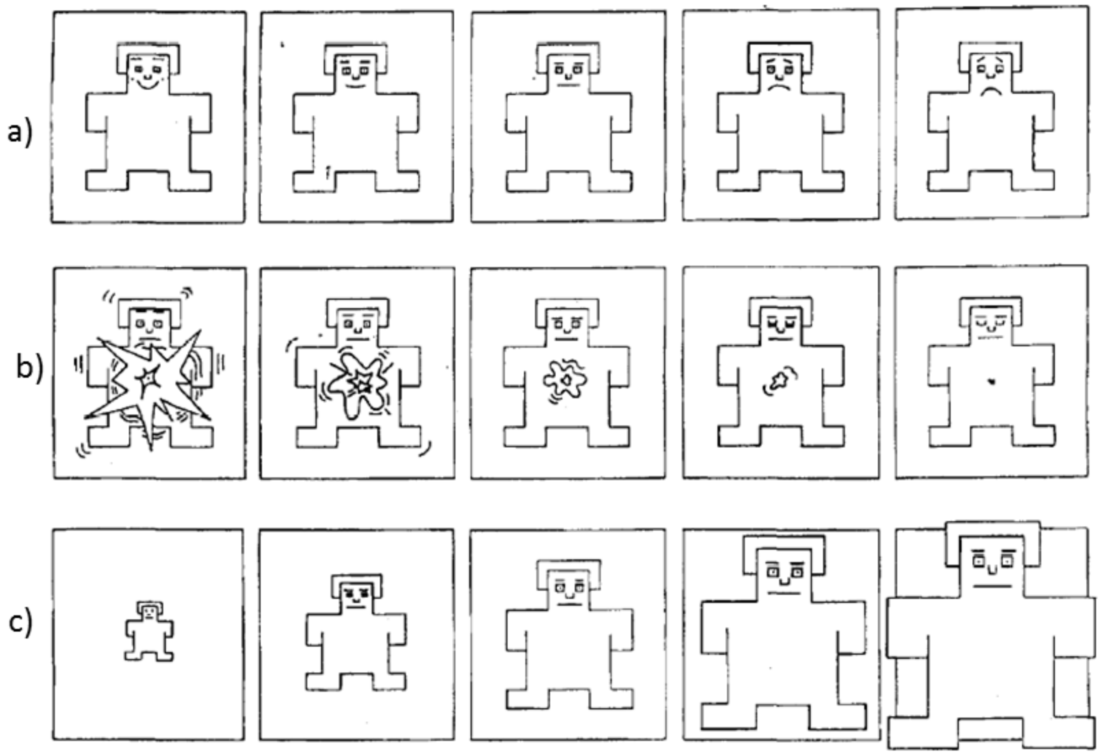


Figure 34. Self-Assessment Manikin (SAM)

a) Measures Pleasure; b) Measures Arousal; c) Measures Dominance
Figure adapted with Figure from (Lang & Bradley, 1994)

As can be seen from Figure 34, the instrument is composed of three panels with five figures each. The panel on top measures the pleasure dimension, and ranges from a smiling and happy figure to a frowning and unhappy figure. The panel in the middle is used to measure arousal and ranges from an excited, wide-eyed figure to a relaxed, sleepy figure. The panel on the bottom measures dominance, and associates changes in control with changes in the size of the figure: the smallest figure indicates the minimum control of the situation, while the largest one indicates the maximum control of the situation. In this version of SAM, viewers can place an 'x' over any of the five figures in each panel, or between any two figures, which results in a 9 point rating scale for each dimension (Lang & Bradley, 1994).

3.4.5.2. Hedonic Quality

This research was based on the belief that enjoyment is fundamental to life. Thus, software systems, in general, should be designed in order to be enjoyable. It has been demonstrated that 'hedonic qualities' (which are qualities not related with the tasks, as for instance, novelty or originality) should play a role in the development process. It has been shown that the use of 'hedonic' components as graphics, colors and music increase an information system enjoyment and usage (Hassenzahl *et al*., 2001). As can be seen in Figure 35, a tool proposed by Hassenzahl *et al*. (2001) comprises seven pairs of adjectives which characterize the presence or absence of hedonic qualities. Each pair of adjectives corresponds to opposing adjectives, as good-bad, and is evaluated in a 7 points rating scale. After viewers classification of the software on each characteristic, an hedonic quality 'value' is calculated through the sum or average ratings.

Outstanding	☐ ☐ ☐ ☐ ☐ ☐ ☐	Second-rate
Exclusive	☐ ☐ ☐ ☐ ☐ ☐ ☐	Standard
Impressive	☐ ☐ ☐ ☐ ☐ ☐ ☐	Nondescript
Unique	☐ ☐ ☐ ☐ ☐ ☐ ☐	Ordinary
Innovative	☐ ☐ ☐ ☐ ☐ ☐ ☐	Conservative
Exciting	☐ ☐ ☐ ☐ ☐ ☐ ☐	Dull
Interesting	☐ ☐ ☐ ☐ ☐ ☐ ☐	Boring

Figure 35. Semantic differential for measuring hedonic quality

One of the major advantages of this tool is that it can be applied throughout the design process of interactive systems, from the evaluation of early first sketches or low-fidelity prototypes, to fully operational applications or systems. This tool may be directly used on various software products since it does not need to be adjusted to the product's special features. Thus being, and similarly to the SAM tool, it is recommended for use right after usage of low and high fidelity prototypes in order to capture the experts and viewers immediate feelings in relation to the whole application.

3.5. Summary

This chapter described the conceptual framework proposed to the design of video-based crossmedia interactive services, as the eiTV application. The framework proposed, follows a User Centered Design (UCD) approach and its main stages, namely: analysis and requirements gathering, design, prototyping and evaluation.

The **crossmedia** design challenges found relevant, with a special focus on TV, PC/web and mobile devices, were discussed and include **dimensions** as: changes in cognition modes, the influence of cognitive aspects in multimedia learning and interface design, the challenges of crossmedia interaction (Heterogeneity, Interoperability and Consistency), the different degrees of device redundancy and their synergic use, the main dimensions associated with the design of new crossmedia UI applications and evaluation of existing ones (UI Distribution, UI Migration, UI Granularity, Trigger Activation Type, Timing, Interaction Modalities Involved), usability concerns (related with transparency, adaptability and plasticity) UX (viewers perception of the application as distributed or coherent and the emotional reactions and cognitive effects related to UX), and personalization.

For each device, TV, PC/web and mobile devices, a set of specific issues were addressed as, for e.g., the guidelines to be used in the design and prototyping phases, and in the case of TV, a specific iTV framework was also presented.

The chapter ended with the presentation and discussion of a crossmedia evaluation framewok considered relevant for this type of applications.

"*Vision without implementation*
is hallucination"
Benjamin Franklin

4. eiTV Crossmedia Application

This chapter presents the eiTV crossmedia video-based application designed and developed to explore and illustrate the paradigm proposed in this thesis following the framework described in chapter 3.

A User Centered Design (UCD) methodology was followed extended with our contributions to the design and evaluation of crossmedia applications based on video. The UCD methodology is characterized by taking viewers expectations, needs and wishes into consideration along the whole process (Mao *et al*., 2001). Thus the design process, which occurred iteratively, resulted in improved functionalities and changes into the conceptual model that were divided into three generations, reflecting the main conceptual evolutions. For each generation, prototypes were developed in order to explore, illustrate and test the proposed conceptual model and functionalities in the eiTV application. In what relates to the **First Generation**, the conceptual goal was to explore the design of an application capable to generate, from iTV, personalized web contents as additional information to the program being watched, in response to informal learning opportunities, to be accessed through PC, TV or mobile phone. In the **Second Generation** the conceptual shift was based on a 'beyond iTV' desire as well as with the appropriateness of a portal instead of an isolated application. Thus, this generation is more aligned with the concept of '***CLOUD'***. The paradigm changed due to technological and social factors. Video can be watched anytime, anywhere, from different types of devices. Each device (TV, PC and mobile phone) may be used to watch the video, create the associated web content and access it. Finally, and from a conceptual point of view, in the **Third Generation Prototypes** the keyword is ***MOBILE*** and the flexibility inherent of being mobile with the co-existence of different devices and contexts of use. The goals were to take the best advantage: from mobile phones, in terms of mobility and specific features and from their synchronization with other devices (complementarity).

4.1. Global Analysis and Requirements Gathering

To start this chapter, important information was gathered, about TV genres and programs, and target viewers, in a preliminary phase. This information, which is part of a generic requirements analysis, is useful to all the generations. As to each generation, in particular, three stages were completed and described: analysis and design (considering that each generation has its own specificities), prototyping and evaluation.

4.1.1. TV Genres and Programs

For prototyping and evaluation purposes, there was a need to select and classify the television program considering that certain genres are more "compelling for interactivity" (Lamont, 2003a) and some are more compelling for communication between viewers (Abreu, 2007; Geerts et al., 2008) than others. We adopted Livaditi *et al*. (2003) classification: documentaries belong to informational and transactional applications and thus cover instrumental and cognitive needs, thus, the design of interactive applications for this type of program genre should contemplate entertainment and communication elements, in order to be easily adopted by the mass audience; while films belong to entertainment and communication applications and thus cover ritualized needs. According to Geerts *et al*. (2008) both genres are more suitable for asynchronous social iTV, since people talk less while watching them. Since the intention is to develop an iTV application capable to respond to informal learning opportunities created by the program viewing, our choice was to use a film and a documentary. Both genres provide information and induce a state of attention adequate to this informal learning attitude.

In order to choose a documentary and a film that could be highly appreciated, a questionnaire aiming to collect their preferences (see Annex A) was used with 243 people (mainly students from ESCE: College of Business

Administration) aged between 18 and 44 years old. The options available for the documentary category were: animal life, natural phenomena, paranormal phenomena, space, physics, human body or other. The preferred option (57%) was a documentary about space. The most common justifications were: “it’s different”, “it’s new”, “it’s something that everyone dreams to know more about”, “it’s something very far and thus mysterious”, “it’s thrilling because it’s something that we cannot usually see”.

The options available for the film category were: specific series, action, police, horror, comedy, romance, science fiction and drama. Within these options, the ones available for the specific series category were: Dr. House, CSI, Doctor in Alabama, Bones, etc. The preferred one was specific series, namely, the popular CSI series (62%). The more common reasons were: “it’s very thrilling”, “it’s very cool”, “it’s the best series on TV at the moment”. This preference is in accordance with a recent study about people’s habits on TV viewing. They noticed that the lower the age of the respondents the higher the tendency to watch TV series (Lima, 2011).

4.1.2. Related Websites Analysis

Beyond the programs themselves there are meta-program contents, such as blogs, guild pages, social network sites, strategy guides, and so on. Most of this content is program provider-created but some are viewers-created. The amount of meta-programs available varies a lot depending on each program genre, and inside a genre, depending on the program itself. As an example, games are usually the ones with most meta-game content, followed by entertainment programs (as Dr. Ozz and Oprah) and series.

A research was conducted in order to evaluate existent meta-programs contents on CSI and documentary about space, with the following results:

For CSI, an official website usable and with interesting interactive features is available at CSI (2012a). The website comprises information on three CSI titles: CSI Las Vegas, CSI Miami and CSY NY. Each title comprises the correspondent seasons, and inside each season all episodes are available. The users may buy the desired episodes, see many images and, if registered, access generic and informative videos (not specific episode trailers). The website also comprises detailed information on each actor (marital status, name of husband/wife, number of children, where s/he lives and birth date. Concluding: there is no content specific additional information, only information about the actors and the mentioned generic informational videos. There is also a tab with some small excerpts of video (pretty much like trailers) and a tab with games.

There's another website available at CBS (2013), which belongs to the CBS Mass Media Company. As available information, a photo gallery, transmission dates, episodes gallery where all of them (from all seasons) are described in text and illustrated with a picture (no trailers available). Users are allowed to comment, add to their Facebook likes, etc. Different types of videos are available: some excerpts of 2/3 minutes videos resembling some sort of 'best of' moments; CSI related videos, as for instance actors comments on the series, and very few entire episodes from 2011 with approximately 45 minutes each. However, these videos may only be watched from those in a near geographical area within USA. The website also includes discussion forums, a tab with information on each actor (photo, name, series where s/he already participated and received awards), a tab that describes the essence of the series and a blog. A viewer generated content (in this particular case, a blog) was also found at CSI (2012b). Concluding, on the visited CSI websites, no real extra information related with each particular episode was available, or inside an episode about a specific situation. No personalized extra content is provided in any sense. The contextualization exists considering that the related websites comprise general information on the series, photos and some generic videos, meaning that much more can, and should be done, as for instance the eiTV personalized crossmedia application that is being proposed.

As to the documentary category about space, no specific web sites were found.

4.1.3. Viewers Characterization and Selection

In a research study about the use of Internet, Lafrance (2005) found out that the category of users more committed to the simultaneous use of TV and Internet services were the ones between 15 and 25 years old, since they already had that practice more deeply enrooted.

Later, another study (Quico, 2008) with people between 12 and 18 years old, also demonstrated that, in spite of preferring the use of Internet and mobile phones, watching TV was an important and significant activity for them (94,7%), which was done in a daily basis, and occupied a significant part of their free time (64,4% watch TV between 1 and 3 hours a day). It was also possible to observe that the most traditional pattern in this group of young people is the realization of one or more activities at the same time while watching TV, which, in some points, reinforces the conclusion of Lafrance that young people are a category of users very committed to the simultaneous use of TV and Internet services.

A recent report from Paisana & Lima (2011) shows that, similarly to previous years, the use of internet is strongly related to users' age and literacy: The use of the Internet decreases when the age increases and literacy decreases. As an example, in Portugal, 90,6% of respondents between 15-24 years old use Internet, against 5% of respondents above 65 years. 97,5% of respondents with very low literacy do not use internet, while 96,9% of university community (students, post graduate, PhD, etc.) use the Internet.

A more recent study from Strover *&* Moner (2012) demonstrated that the most recent generation of college students, ranging from 18 to 22 years old, views television programming very differently than previous generations. They are no longer just seated in front of a TV set. In fact, their viewing habits "could be characterized as anything but stable" (Strover *&* Moner, 2012). This population usually engages with various devices to watch television and video content, and they frequently respond to the content through exchanges with friends. These exchanges are many times through their own productions on youtube, and they usually follow TV via online services. Nowadays, a typical student's media environment includes YouTube videos, Facebook frequent updates, sharing pictures, producing personal videos, using content libraries available on Netflix and Amazon (depending on the country), twitter feeds, instant messaging, chat, blogs and many others. This audience is no longer committed to the flow of programming available in a traditional set configuration but, instead, to access content on-demand.

The focus of the eiTV application was on the population with more technological literacy, which, as stated in (Lafrance, 2005; OFCOM, 2012; Paisana & Lima, 2011; Quico, 2008 and Strover & Moner, 2012), is typically found on younger populations. However, considering the importance of the lifelong learning trend, the application was also tested with other populations, namely, older people, and also those with lower technological literacy. Considering that the author of this thesis teaches in the College of Business Administration (ESCE), a college with students above 18 years old, it was decided to choose the participants mainly amongst the students. As to the number of candidates that wanted to participate in this project, it was a good surprise: we had 57 candidates from the Information Systems Management Degree (ISMD), 41 from the Marketing Degree (MKTD), 35 from the Human Resources Management Degree (HRMD) and 27 from the general public (non-students). All the candidates, with the age ranging from 18 to 60 years old, filled a specific questionnaire (Annex B) with questions about their demographic profile data (e.g., age, sex, socio-economic status); viewing patterns (e.g., social viewing, routines, preferences), technological literacy (e.g. TV, PC, mobile devices and internet habits of viewing and use). In sum, the questions were focused on their habits in terms of TV, PC, mobile devices and internet use (e.g. how often do you use TV? Do you use it simultaneously with other devices? How many hours/day do you use the internet? For which activities? Do you use Facebook, or equivalent? Do you use smartphones? For which activities?). Based on the answered questionnaires it was possible to characterize viewers in terms of technological literacy and, based on that, select: 15 students from ISMD with higher technological literacy; 15 students from MKTD with less technological literacy and 20 persons (15 from the general population, also designated as public and meaning non-students, and 5 students from HRMD) with lower technological literacy. In the groups of students the age ranges from 18 to 44 and in the group of public the age ranges from 18 to 60 years old. There was also a group of experts 8 experts that collaborated in the de design process and evaluation. They were selected from the HCI and iTV academic research areas and 7 are university teachers. In this group, the age ranges from 34 to 58 years old.

These viewers and experts participated in the design process and especially in the evaluation phases along the three generations, as described in Table 3.

.

Table 3. Viewers and Experts participating along the Three Generation Design Process

	First Generation	Second generation	Third generation
Low fidelity prototypes	- 3 experts: (2 HCI + 1 iTV); **E1** - 15 students 5 ISMD 5 MKTD 5 HRMD **V1**	- **E2 = E1 + 2** iTV new experts **- V1**	- **E3 = E2 + 3** HCI new experts 20 students and 10 from the public: 10 ISMD (c); 10 MKTD (c); **V3** 10 public (c). *(c) 5 from the group **V2** + 5 new.*
High fidelity prototypes	- **E1** - 20 students and 10 from the public: 10 ISMD (previous 5 + **5 new**); 10 MKTD (previous 5 + **5 new**); 10 public (all new).	- **E2** 10 students and 5 from the public: 5 ISMD (a); 5 MKTD (a); 5 public (b). **V2** *(a) the ones that were new in the previous evaluation;* *(b) from the previous 10, these 5 were the ones with more difficulties in using the application.*	**- E3** **-V3**

As may be seen in the table, the number of viewers involved in each evaluation moment was between 15 and 30. These numbers are not a representative sample (due to the financial and logistic constraints that the situation would imply) but instead is a skewed sample (Ghiglione & Matalon, 1993) in (Abreu, 2007). Nevertheless, the use of a skewed sample would allow to reach significant conclusions in what concerns the identified evaluation goals.

4.1.4. Crossmedia Requirements and Design Dimensions

In chapter 3, the relevant dimensions found in the analysis and design stage of a crossmedia application were identified and explained in detail. These dimensions, which should inform the design of this type of applications, are summarized here, to facilitate the understanding of the design options made in order to accommodate them.

- **Different cognition modes**: experiential, the mode of perception and entertainment or reflective, the mode of reasoning and contemplation;
- **cognitive theory of multimedia learning design principles**: Split-Attention, Modality, Redundancy, Spatial Contiguity, Temporal Contiguity and Coherence principles;
- **Heterogeneity**: different media and contexts of use;
- **Interoperability**: shows how the system works, how each role is supported by each medium, and how functionalities are distributed. Sometimes referred to as 'composition';
- **Consistency**: should be perceptual, lexical, syntactical and semantic to a consistent look and feel;
- **Continuity**: is considered to depend on how well the system supports cross-platform transitions, task migration and synchronization. To assure continuity, active interaction strategies - as crossmedia referencing: interactive situations on one device suggest connections to other devices within the same system - are needed. Continuity supports Interoperability;
- **Contextualization**: refers to strategies created in order to help understand the sequence of events and the relation between them. Contextualization supports continuity;

- **Device redundancy**: how the roles of devices may be organized within a crossmedia application (redundant, complementary and exclusive);
- **Synergic use**: what is possible to achieve with the reunion of devices is higher than what would be achieved through their individual use;
- **Crossmedia UI**: Distribution, migration, granularity, trigger activation type, timing and interaction modalities involved;
- **Usability**: is the extent to which a product can be used by specified users to achieve specified goals with *effectiveness*, *efficiency* and *satisfaction* in a specified context of use;
- **Transparency**: allow viewers' understanding of the system;
- **Adaptability**: also defined by some authors as Plasticity, is the ability of UIs to adapt to a context of use which includes user, platform and environment;
- **Flexibility**: the capacity of the system do adapt to different devices, users needs, contexts of use, etc. In spite similar to adaptability is a broader dimension;
- **UX**: extends the usability perspective towards emotional aspects of system quality;
- **Coherence**: the perception of an application as a whole, may be achieved through consistency;
- **Personalization**: the ability of a system to be adapted to users preferences manually or automatically;
- Devices and contexts of use **levels of attention, levels of TV viewing, affective dimension** of TV viewing, **goals** and **needs**.

4.2. eiTV First Generation: Web Content from iTV

The conceptual goal in the first generation was to explore the design of an application capable to generate, from iTV, personalized web contents as additional information to the program being watched, in response to informal learning opportunities, to be accessed through PC, TV or mobile phone (in terms of **devices redundancy** PC and mobile were used as exclusive devices while iTV was used in a redundant way). The three phases: analysis and design, prototyping and evaluation are presented in the next sections.

4.2.1. Analysis and Design

The goal of the first generation was to generate from iTV, websites as additional information to the program being watched to be accessed and watched through PC, TV or mobile phone (one departure point and three arrival points), for use scenarios like the following:

> *John is a university student. He arrives from school and, after dinner, by chance, he comes across a documentary on TV that addresses topics related to what he is studying in Economics. He is very interested in knowing more about a certain number of those topics, so he uses the eiTV application in order to select them, just by pressing the enter button on is remote. He is tired so he is interested in an interactive mode not intrusive of the TV experience, in order to select some topics along the viewing. The application prepares a web content based on the selected topics with extra information. That web content is stored for immediate or later view and may be shared with his friends. Since it's late he decides to access the web content from his mobile phone, while in the train to the university next morning, and later on from the PC.*

The identification and study of possible scenarios is an important part of the analysis and requirements gathering phase, in order to identify important factors that need to be considered in the design phase to produce efficient applications and a first step towards a good application design is the identification of **functional** and **non-functional** requirements.

As to functional requirements, in brief, the simplified scenario is the following: while watching a TV program, typically in an experiential cognitive mode, the viewer is able to select the specific topics of interest (related to the program content and meta-information, or metadata), for further access and learning in a more reflective cognitive mode. Thus being, the application should be able to generate extra related webc ontents from the selected topics of interest providing the adequate support both for the iTV topics selection and web content view from iTV, PC or mobile phone.

The study of the conceptual framework in chapter 3 identified a considerable number of dimensions in the cognitive, affective, communication and interaction areas, informing the design of crossmedia applications, and thus, becoming important requirements. In relation to the non functional requirements, they are summarized in section 4.1.4.

A UCD approach for the eiTV application design was followed (Chorianopoulos & Spinellis, 2006; Nielsen, 1994; Norman 2002; Prata *et al*., 2006). All options made in terms of design are explained. They explored to meet the most relevant challenges involved in the interaction with the different media and devices that are integrated.

4.2.1.1. Conceptual Model

The conceptual model defines the system image, how it will look like and act. The iTV selection of interest topics is possible through interfaces, which differ in terms of level of detail, number and type of available options, complexity and more or less intrusion in the iTV experience at accommodating viewers' changes in cognition modes. A personalized web content addressing all the selected topics and related web links is generated by the application, in a server, and made available to the viewer, via the Internet, in a format to be viewed on different media or devices: PC, iTV and mobile phones. Viewers' may choose how they wish to be informed about the web link address to the web content: if through e-mail, SMS, or both. If the viewers' choice is to access the web content through the iTV, the link is immediately available via the iTV application.

These web contents are designed to satisfy the viewers' information needs, by containing more information in breadth, depth, and points of view than the original broadcast content, on the aspects directly related to the chosen content topics and program metadata. Thus, it provides an answer to the learning opportunities created by the entertainment environment of TV, involving different media and, instead of being seen as the end product, the broadcast program can be the starting point to a crossmedia dynamically built learning space, a new crossmedia learning context (environment) to be further explored. It will also allow viewers to share their web content with their contacts, as a way to fulfill their communication needs while watching TV - a concept that was referred to, by Geerts *et al*. (2008), as "social TV" and that is growing due to the proliferation of different technological communication devices. In fact, since TV works as a promoter of interpersonal communication (Abreu, 2007) and t-learning has social features (Aarreniemi-Jokipelto, 2007), this communication functionality turns out to be important.

4.2.1.2. Application Architecture

A Client-Server architecture was adopted for the eiTV application (see Figure 36). The server stores a database of the: information modules delivered to create the web contents; TV content meta information; viewers profiles, and the specific templates to be used for each device. These templates are responsible for formatting the information to be presented to the viewer and, the application selects them, essentially, based on the type of the access device and the viewers' profile, in order to personalize the application. The server also stores the web content generated by the application. The interactive backoffice runs on the server, accessed from web browsers running on the devices, allowing to select topics and create web contents (from iTV) and to access it (from the three devices).

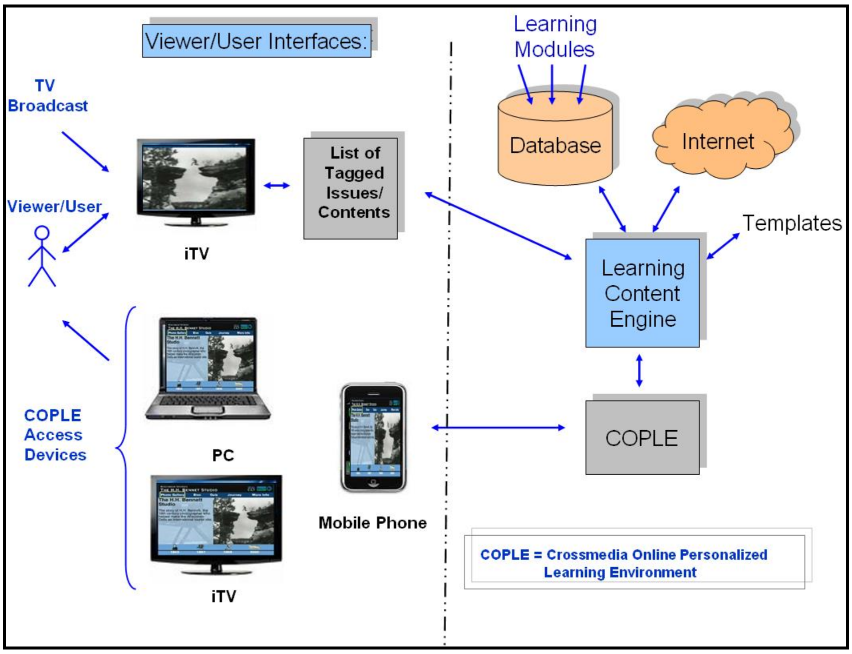


Figure 36. eiTV First Generation Architecture

The web contents are constructed dynamically, based on the viewers' choices and profiles, with information from two different sources: information modules and web links. The modules, developed under specific standards in order to be adequate to the server database, are supplied to the TV broadcaster in addition to the TV program. These modules provide a way of reusing resources. Producing TV programs is very expensive and, due to time constraints, the amount of produced material is usually higher than the one that is actually used. Thus, we have proposed an application where that superfluous material may be used in informal learning modules. These modules will be complemented with information from reliable websites related with selected issues as links made available at the bottom of the web content that was generated.

4.2.2. Prototyping

This section is mainly dedicated to the description of high fidelity prototypes. However, and in order to justify some design choices, some low fidelity prototypes evaluation results are also mentioned along the text. Thus, and although there is a specific section entirely dedicated to the description of the evaluation goals, methods and results (section 4.2.3.), the present section also includes evaluation results, namely the ones from the low fidelity prototypes where needed. Considering that this information helps understanding the high fidelity prototypes design choices explained next, this option was made in relation to the three generations presented in this thesis.

As to the evaluation method in general, the framework proposed in section 3.4. was used. In what relates to the evaluation of low-fidelity prototypes it is described in section 4.2.3.1. and the evaluation of high-fidelity prototypes it is described in section 4.2.3.2.

The eiTV interactive features were designed to explore the support to the generation of web contents, from iTV, based on viewers specific topics of interest and are described in the following categories: 1) Personalization; 2) Interacting with the TV program; 3) Final choices, share and confirmation interface, including the possibility of sharing web content with friends and 4) Personalized web content interface generated in the crossmedia environment.

Most of the crossmedia design challenges are related to 2) and 4), the interaction with the program and the **contextualization** in the generated content, so the design of these features received more attention, as described in sections 4.2.2.2. and 4.2.2.4). The iTV interfaces were designed based on the iTV framework proposed by the authors (see section 3.2.4.1.) and the web interface was designed based on the directions described in section 3.2.4.2. Both interfaces were later adapted and improved according to evaluation feedback. Designed options accommodate different viewer's cognitive modes, levels of attention, goals, needs, interaction preferences and affective dimension.

In technical terms, and when referring to high fidelity prototypes, no software tool was used to migrate the software from one device to another, meaning that there was no UI automatic **distribution**. In fact, all interfaces were manually designed and developed using a list of programing languages and software. The programing languages were: ActionScript for the application, PHP to the server side, MySQL to the database, HTML/JavaScript/CSS to the web content. As to the software used: Flash to the application, Eclipse to the server and web page, PhpMyAdmin to the database configuration and Cpanel to the server configuration (more technical details in Annex O). In these prototypes users select what, when and to which device the UI should be changed. Thus being, this is a user **trigger activation type.** As to the **timing** dimension, the **migration** occurs **immediately** after being triggered by the user (for e.g. in the case of the web content, it may be accessed later but in technical terms it is generated immediately when asked by the viewer).

Prototypes were designed and implemented with the documentary about space and the CSI series as basic content. In general terms both TV genres prototypes had the same categories of features (personalization; interacting with the TV program; final choices, share and confirmation; web content interface). However the first prototypes to be implemented were the ones on the documentary about space, which differ in terms of dynamics when compared with the CSI series. In fact, due to its informational nature, documentaries cover cognitive needs and it is very frequent to have more than one topic of interest in each sentence (subtitle). Thus being, in the low fidelity prototypes three was chosen as the maximum number of selectable topics in each sentence as may be seen in Figure 38-b) where three topics were made available in the bottom bar (for e.g. Scientific Fiction, Dinosaurs and Comets) and two were chosen by the viewer (Scientific Fiction and Comets) by pressing the correspondent numbers, in this case, 1 and 3 on the remote. Visual feedback on the viewer's choice was made available through the "✓" character in front of the topic name. As to the CSI in the low fidelity prototypes one was chosen as the maximum number of selectable topics in each sentence.

For each of the four identified features categories a comparison between the Documentary and the CSI is presented next.

4.2.2.1. Personalization

eiTV allows personalization of the service and adaptation of the generated web content to each viewer. After login, viewers may choose what to use, traditional iTV services or the eiTV application. When using the eiTV application for the first time, viewers are asked to register and define their profile (from iTV and via a wireless keyboard (nevertheless, the information input via the wireless keyboard may be easily adapted to a virtual keyboard or even to a mobile phone keyboard if used as a second screen). The profile includes personal data and preferences like gender, age, e-mail, mobile phone number, interests, the way in which viewers want to be informed about the web content location or web link, which device(s) they want to use in order to access it, etc. (see Figure 37).

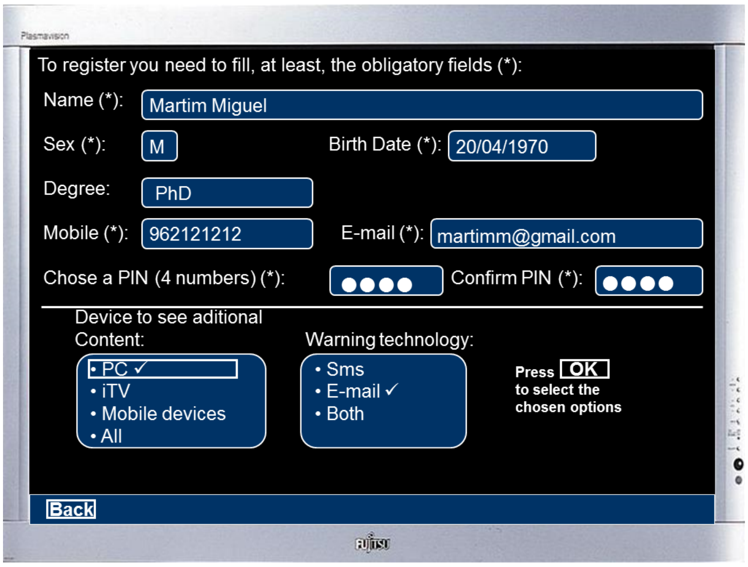


Figure 37. Personalization from iTV

The design and prototyping of this feature was identical for both genres (documentary and CSI). This feature provides the application with **personalization** and flexibility. The Viewer's profile may be changed at any time, thus being prepared for changes in viewers' **goals, needs** and providing the application with **flexibility** and **adaptability**.

4.2.2.2. Interacting with the TV Program

To interact with the TV program, the viewer needs to enter the interactive mode. During the first three minutes of the program, the interface presents, on the top right of the screen, the text "Press Enter to interact", which will be replaced by "Enter" after that period. The word "Enter" remains on screen for one minute. Then, while not selected and until the end of the program, it appears for ten seconds every five minutes. These time values were the ones considered more adequate when tested through a power point simulation in low fidelity. This solution, implemented in both genres, will keep the viewer aware of the application presence, something fundamental to the success of a crossmedia system (Segerståhl, 2008), thus providing the application with **coherence** (assuming that viewers will perceive it as a whole) and **transparency** (assuming that viewers will be able to understand how the application works) and in accordance with the **spatial contiguity design principle** (which states that it is easier to learn when the on screen text and visual materials are physically integrated). The interface was tested on low fidelity through power point simulations in order to evaluate if it would be distracting from the video. But, as viewers referred, they are used to large amounts of dynamic text (e.g. the bottom bar of news programs) so this particular word was not considered intrusive on the iTV experience, but helpful in order to remind them that the application was there thus providing **accessibility** to the application interface. Nevertheless, their opinion was considered as merely indicative taking into account that they were not really watching TV, they were seeing a power point static image.

To access additional information along the program, on the *documentary* prototypes, we have proposed a simplified interactive selection of topics (see Figure 38). If interaction is selected, by pressing enter, viewers enter a new mode where they may choose their topics of interest for further information. On this interface, the selectable topics are presented to the viewer through numbers from one to three (chosen topics in Figure 38-b) were 1 and 3, the ones with the visual feedback: ✓).

a) Interface to enter interactive mode b) Interface for Content selection

Figure 38. Enter Interaction Selection of Topics Mode

As previously mentioned, the documentary has a dynamic nature due to the amount of available information, much higher than from CSI. Usually, there are several topics of interest in each sentence or subtitle. Thus being, and considering that the bottom bar was already filled with three written topics (the preferred interface option in low fidelity prototypes), no extra space was available for other interaction options.

On the *CSI* prototype, due to its entertainment and communicational nature, ritualized needs, more than cognitive needs, are covered. Thus being, the maximum number of topics of interest for each sentence was in average one and, not every sentence had a topic of interest. Thus being, in low fidelity it was decided that only one topic would be selectable in each sentence. This decision allowed to propose more elaborated interaction interfaces where numbers were used to access different information levels instead of used to select topics (Figure 39). As to the selectable topics, they were underlined within the subtitle and a simple enter would be enough to choose them. It was decided, in low fidelity, that the underline suggests links and thus, in terms of usability, it would be the most adequate option in order to indicate the selectable topics. To accommodate viewers' changes in **cognition modes** and **needs**, we have designed an active selection interface comprising two types and three levels of information as described in the next sub-sections.

4.2.2.2.1. Information Types

Information made available about the TV program can differ in focus and scope:

- ***TV Content***: refers to information on the TV program content, and what is being said, as presented in the subtitles, where some specific selectable topics are highlighted from time to time;
- **TV Meta-Info**: refers to meta-information categorized as: *specific and dynamic*, the one that changes along the program and comprises information about the on screen scene, actors on the scene, props, shooting place, private jokes – as a specific case of meta-info, etc.; or *general,* the one that relates to the whole program, as information about the producer, director, actors, inspiration for that program, etc.

Both types of information were made available on the three proposed interfaces for the information levels, as presented next.

4.2.2.2.2. Information Levels

In what relates to the ‘TV content’ information type, in order to accommodate viewers’ changes in **cognitive mode**, **levels of attention**, **goals**, **needs** and interaction preferences and **personalization**, they were able to choose among three levels of interaction and detail, from less to high informative:

Level 1. Topics: the lowest level of detail, requiring less viewer attention, probably easier to follow and understand, where viewers are supposed to select their topics of interest without having immediate extra information. The viewers maintain the typical experiential cognitive mode (the one that allows to perceive and react to events efficiently and without effort, the mode of expert behavior, perception, entertainment, inspiration and motivation) while they watch the TV program, delaying the exploration of the selected additional information in a more reflexive mode (where they can engage in reasoning and thought) to a later time. This level only implies the use of the *enter* button in order to select topics of interest. Each subtitle has, at most, one selectable topic, which will appear underlined (see Figure 39). Familiarity was considered, since underline is often associated with links e.g. in the web. The feedback on viewers' choice is, once again, provided by a checked box that appears, now in front of the subtitle. In the example presented in Figure 39-b it is possible to see, through the visual feedback "✓" (in front of the text at the bottom bar), that the viewer's choice was information level 1.Topics and from Figure 39-a that the selectable topic presented in the subtitle was DNA (since it is the only word underlined) and it was chosen by the viewer, having the checked box appearing in front of the subtitle;

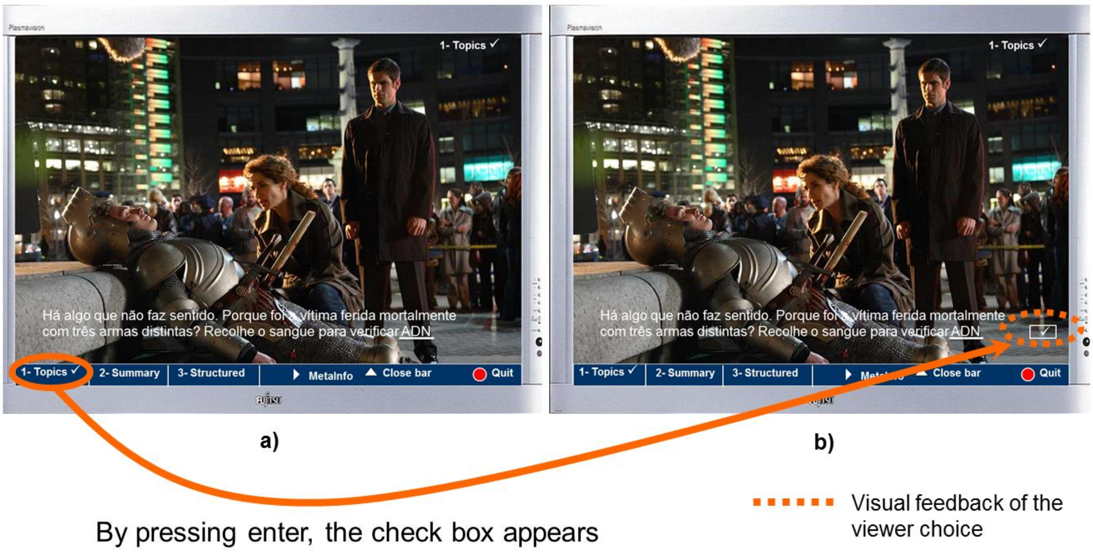


Figure 39. Level 1: Topics information

a) Information level choice Interface (with level 1-Topics being selected; b) the Topic DNA was selected.

Level 2. Summary: a higher level of detail, more informative and requiring more attention from the viewers, where they are presented with immediate additional information as a brief summary about the topics, *overlaid* or *embedded* on the screen, depending on the viewers' preferences. The information was made available both in overlaid and embedded on the screen, considering that these are the main choices for interactive TV and video, as supported by the iTV framework proposed (see section 3.2.4.1). On the overlay design, the video always displays in full-screen mode, so that the interactive content is placed over top of the screen. On the embedded design, the video area is reduced so that content is placed around it. In any case, the video automatically pauses, while the information is being shown, a decision that was based on the preferred option from the low fidelity prototypes evaluation. In addition, viewers still have the option to select that topic to generate a more detailed web content to be accessed at a later time (see Figure 40);

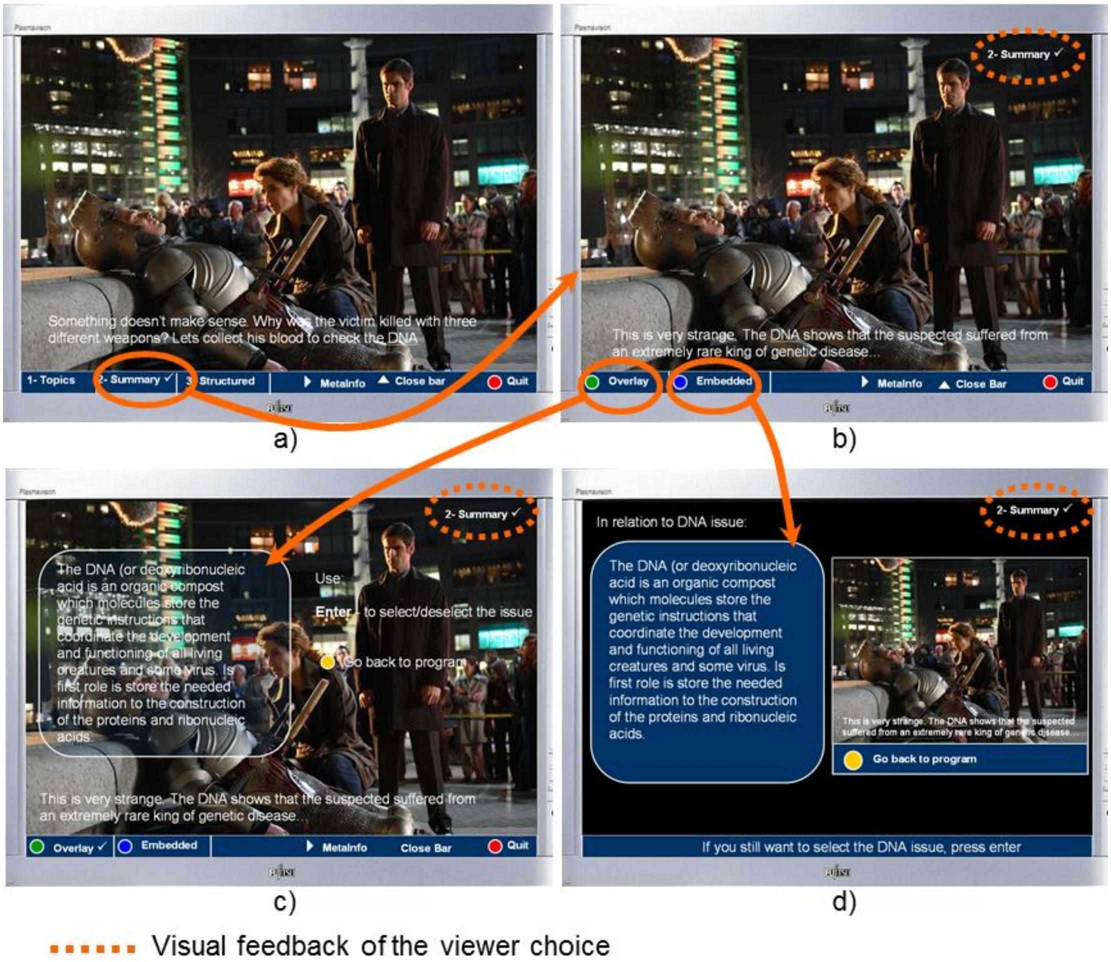


Figure 40. Level 2: Summary Information

a) Information level choice Interface; b) Interface when level 2 (summary) is chosen; c) Summary information overlaid on screen; d) Summary information embedded on screen.

Level 3. Structured: the highest level of detail, very informative and requiring a high level of attention from viewers. They are presented with immediate extra information, namely a structured list of main aspects or sub-topics about that topic that the viewer may choose from, *overlaid* or *embedded* on screen. In any case, and as decided for level 2 based on low fidelity evaluation, the video pauses while watching information about the topics and choosing them and the viewer may select aspects from that topic list (for e.g. History, Properties and Biological Functions from the DNA topic list) to get additional information about the different aspects of the topics as generated web content to be explored at a later time (see Figure 41).

Visual feedback of the viewer choice

Figure 41. Level 3: Structured Information

a) Information level choice Interface; b) Interface when level 3 (structured) is chosen; c) Structured information overlaid on screen; d) Structured information embedded on screen.

At any moment, the viewer is able to change between levels of information by pressing button 1, 2 or 3 on their remote (see Figure 41-a) which aims to provide the application with **flexibility** and **adaptability**.

In sum, presenting two types of information about the TV program, which differ in focus and scope, and three levels of interaction and detail, from less to high informative, prepares the application for changes in **cognition modes,** provides the application with **flexibility**, **adaptability** and is prepared for changes in viewers' **goals**, **needs** and **attention levels**.

4.2.2.3 Final Choices, Sharing and Confirmation

At the end of the TV program, or when selected, the application presents the interfaces for the final choices, as explained next.

4.2.2.3.1. Information and Device Confirmation

This option presents the complete list of available TV Content topics and sub-topics, highlighting those that were selected while watching the TV program, to be accessed in more detail in the generated web content. Viewers may change their selected topics at this point, and may select additional meta-information to be included in the web content. They also have the possibility to change aspects obtained from their profile, like the device(s) they want to use in order to view the web content and the way to be warned about the web content location (sms, email or both), or cancel the web content production (see Figure 42). If the TV program ends, or if viewers decide to stop watching the program by pressing the quit button, they are automatically led to this interface, supporting changes in viewers' **goals**, **needs** and **attention levels.** This feature was implemented in both prototypes genres.

4.2.2.3.2. Web Content Sharing

This feature, implemented in both prototypes genres, allows viewers to share their web content. They are able to choose from a list of options, including social platforms like hi5, Facebook or LinkedIn (see Figure 43) and to share the web content with all their contacts or only specific ones which they have to select. Both options were made available to provide **flexibility** and **personalization** to the application. Viewers also have the possibility to add a text message to the web content being shared, which will be received by their contacts, as an e-mail. The e-mail, instead of just containing the link to the generated web content will also include that message. This functionality was developed in order to accommodate the viewers' **affective dimension** in TV viewing in terms of integration and social interaction.

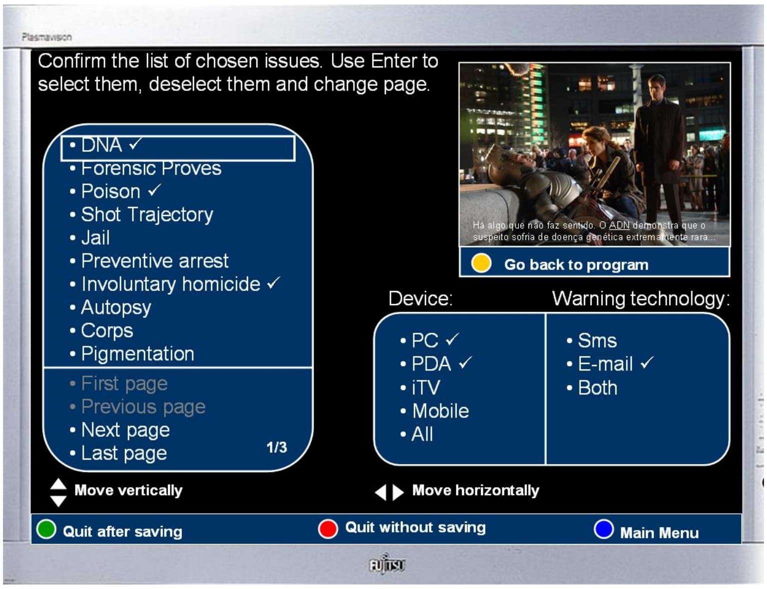


Figure 42. Information and device confirmation interface

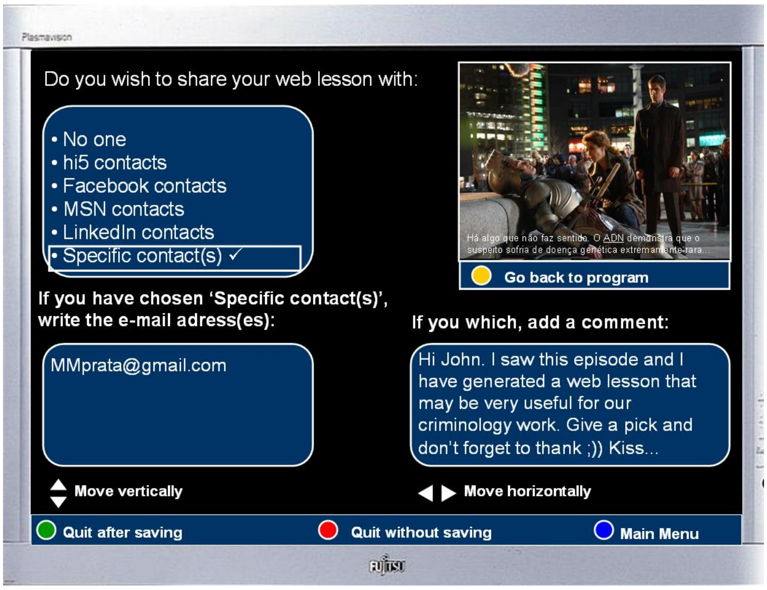


Figure 43. Web content sharing interface

4.2.2.3.3 Default Service Finalization

If the viewer turns off the TV or changes channel before the end of the TV program, and does not press the quit button, the application will prepare the corresponding web content with the selected issues and will use the warning device(s) defined in the viewer's profile to inform about the web content link. This feature, available in both prototypes genres, was designed in order to accommodate changeable TV viewer's **attention levels** and focus and provide the application with **flexibility**, **adaptability** and support changes in **cognition modes**.

4.2.2.4. Web Content Interface

An important part of our research goal is to explore effective ways of designing crossmedia dynamic informal learning contexts based on cognitive, affective and interaction aspects. In terms of the contents of the generated web, our main concern was to be able to efficiently contextualize the viewer in relation to the original TV program, providing for **coherence** and **unity**, through **consistency** and **continuity**, in the User Experience (**UX**). To achieve this goal, the choice of the look and feel matches the TV program aesthetics and the information included matches the viewers' choices and timings at the TV program. The smooth integration of different media was also taken into account (Chambel, Zahn & Finke, 2004; LiestØl, 1994). In fact, the integration of media was based on new textual information, but related with what viewers watched and heard from the original video, and specific excerpts of the original video and thus already familiar. Thus being, the integration of media was not imposed or forced, was natural in terms of contents, considering that familiar information was merged, and in terms of devices considering that each one was used to do what it does best (TV to watch the video and select topics of interest and the three devices to access the web content) thus assuring **heterogeneity**. Generating web contents with detailed information about what was being watched in the video it is in accordance with Mayers' (2001) **split attention principle**. In fact, in order not to disturb viewers TV experience due to the amount of available information, the web content is generated to be seen when in a more reflective mode, thus providing viewers with more control and **flexibility**.

The generation of the web content interface was made available in both prototypes genres however with different possibilities.

Figure 44-e) shows an example of a generated web content for PC access, presenting more information and points of view than the original broadcast content, designed in the context of the Documentary series. The left side menu contains all the topics selected by the viewer, presented by the order of selection in the TV program, to improve **contextualization**. On the CSI web

contents, viewers may also choose to see topics by alphabetical or logical (content dependent) order thus improving **personalization**. Sub-categories of the topics are presented in the top menu. The CSI prototype was implemented after the documentary one and thus it benefited from its evaluation (described in section 4.2.3.).

Continuity and **contextualization** was further 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, viewers 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, which we believed might help creating a smooth and contextualized transition by reliving the moment of choice on TV. When asked, in low fidelity, about different options of contextualization, namely image or video, viewers agreed that video would be the best option. This option is in accordance with three principles proposed by Mayer (2001): **redundancy principle** which states that is easier to learn from complementing sources as for instance video and narration, the **temporal contiguity principle** considering that the video has verbal and visual materials synchronized, and **modality** principle considering that is easy to learn from audio information than from the equivalent text. Thus, the use of excerpts of video in order to contextualize viewers will also improve viewers learning.

Two options were made available: to have the **video playing** and the **video paused**. When the video is playing, viewers' have the option to pause it and just read the text and, when needed, look at the still image which resulted from the video paused. When the video is paused, viewers' have the option to play it. As to the video excerpt selection, two options were made available: to have the videos beginning at the selection time (which sometimes cuts the sentences), or to begin in a previous position to include a consistent dialog and context (e.g. beginning of the sentence).

Figure 44 illustrates the navigation in the iTV Documentary prototype (a-b, b-c, c-d), and towards the contextualized and personalized web content (b-e) – a "link" that is followed at a later time when accessing the web content.

The CSI navigation explored richer options, regarding the differences in terms of types and levels of information. The main iTV interface difference may be observed in Figure 45, where option a) illustrates the documentary main interaction interface, which comprises information about the TV content, namely, at the most three possible topics to choose in each sentence; and option b) illustrates the CSI main interaction interface, which comprises information about the TV content (through three different levels: level 1- topics; level 2- summary; and level 3- structured) and metadata (MetaInfo). From the 'level choice' interface (see Figure 39-a) it is possible to navigate to level 1 information (Figure 39), level 2 (Figure 40) and level 3 (Figure 41). Since the documentary was the first prototype to be implemented, it was a simpler version (without the two types and three levels of information).

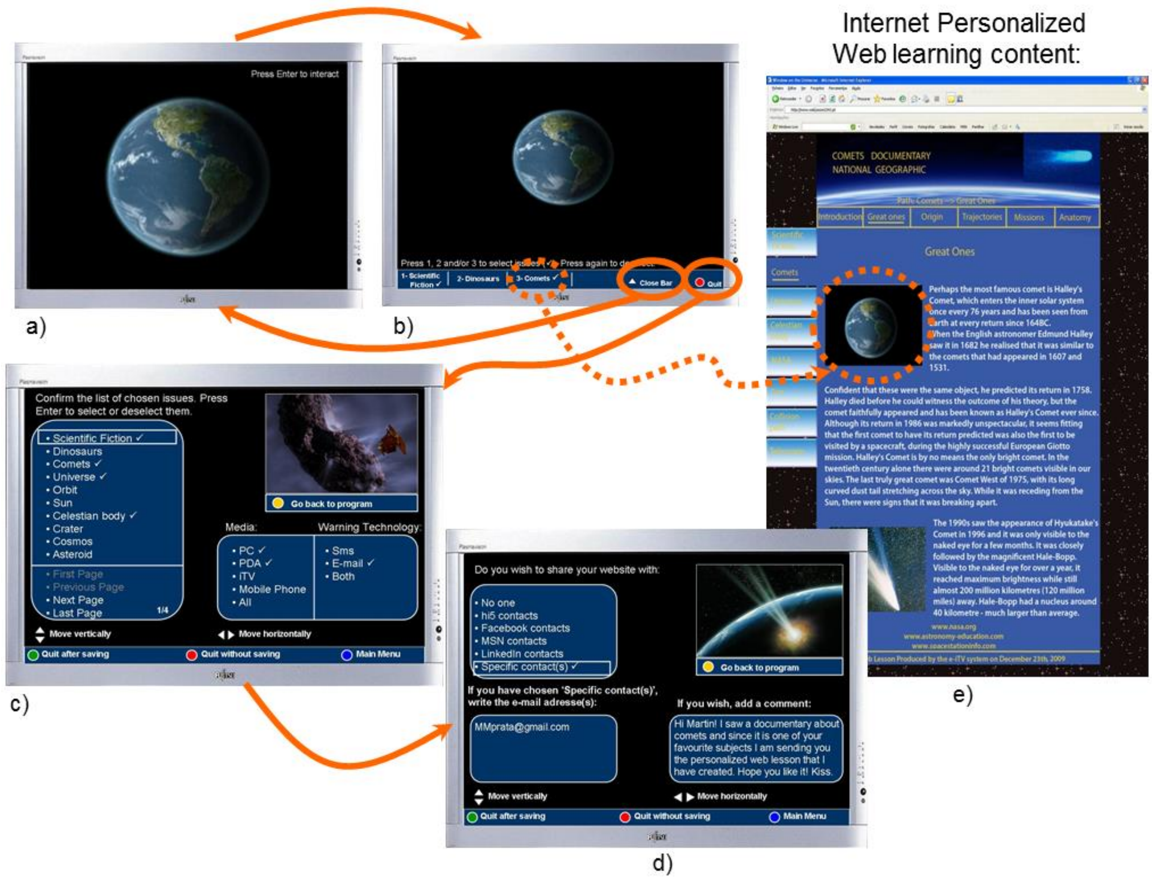
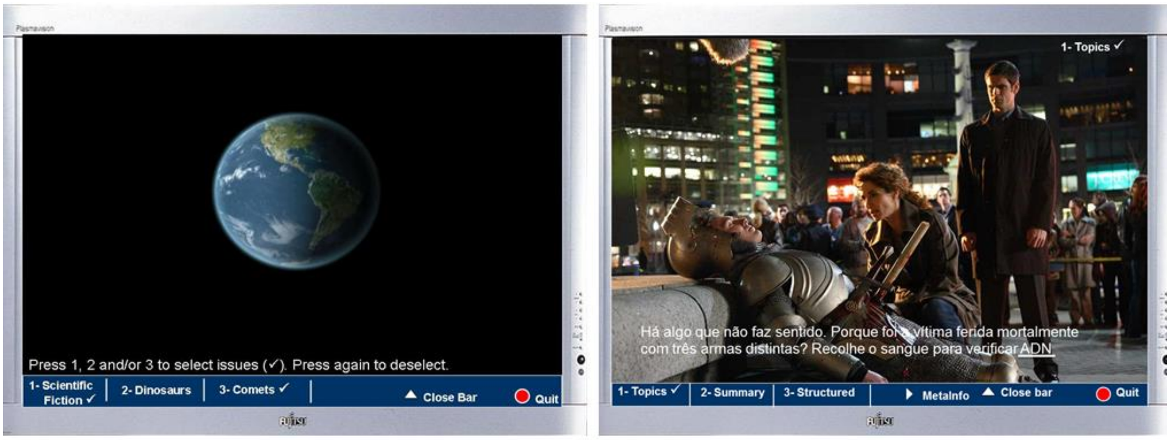


Figure 44. Overview and navigation in the iTV and contextualized web content using video

a) Interface to enter interactive mode; b) Main iTV Interaction Interface; c) Information and device confirmation interface; d) Web content sharing interface; e) Generated Web Content.



a) b)

Figure 45. Documentary versus CSI main iTV Interfaces

a) Main Documentary iTV interface; b) Main CSI iTV interface.

4.2.2.5. Design Rationale Overview

In the crossmedia conceptual framework in chapter 3, a considerable number of variables was identified in the cognitive, affective, communication and interaction dimensions. These variables were considered in the iTV interaction design model (Prata *et al.*, 2006) and were used to plan, develop, design and evaluate the eiTV crossmedia application. To summarize our design rationale for eiTV, some of the most relevant variables and design options are presented next:

1. In terms of **media and cognition,** eiTV was designed to:

- **Support different levels of attention** and cognitive modes and changes among them, **flexibility** and **personalization** through the use of: different types and levels of information, layout styles (overlaid and embedded), flexibility in the finalization, the possibility to choose when and from which device to access the additional generated web content and whom to share it with, the possibility to have the web content generated automatically even if a change of channel occurs or if the TV set is turned off;
- **Accommodate viewers with different levels of technological literacy, levels of interest goals and current attention**, namely through: the use of different information levels (topics, summary and structured) and the possibility to change between these levels when needed; the possibility to deselect previous selected topics or vice-versa from the complete list, just

before generating the web content; etc. This concept is related with **flexibility** and **personalization**. Both navigation buttons and remote control keys (4 chromatic and 4 navigation keys; ok key and keys with numbers 1, 2 and 3) were selected according to the highest probability of usage and also according to their level of intuitiveness to our interface concept.

2. In terms of **crossmedia design**, the interfaces were designed:

- **In accordance with the devices characteristics to take the best of each device**, and achieving **synergic use**. For example, on the iTV interface, due to the limited interaction possibilities associated to the use of a remote control, the number of navigation buttons was made very small (4 chromatic and 4 navigation keys; ok key and keys with numbers 1, 2 and 3), in order to assure an easy use of the functionalities that were identified as most important. Considering the devices characteristics and what each one does best, the iTV is used to watch video on TV, watch content and also to trigger the generation of additional information (since it tends to induce a lean-back attitude or experiential cognitive mode) while the PC or mobile devices were considered the preferred devices to present the generated additional web content (since they tend to induce a lean-forward attitude). Nevertheless, TV was also used in order to present the generated web content in a similar design;
- **To be similar across the used devices in order to assure consistency**. However, in spite of respecting the need of similarity to create a sense of **continuity** (thus providing a good **UI Migration**), the characteristics of each device were also considered. As a concrete example, the web content generated by the eiTV application uses the same colors, buttons and general look (when needed and where possible) but it also takes advantage of the scroll possibility offered through the access via PC and uses smaller font sizes. Figure 44 presents a documentary web content. When compared to the iTV interface presented, it is noticeable that in the web content shown on the PC, the navigation structure changed, considering that different devices are being used as well as different, although related, information with different level of detail. However, some details where maintained in order to help creating a sense of **coherence** and continuity: a space theme template, the colors, the excerpt of the video in the moment of the topic choice and the topics selected by viewers.

- **To support previous experience through familiarity**. Thus, the guidelines and common practices already in use were followed. As an example, when a possible topic of interest comes up in the iTV, it appears underlined in the subtitles, the usual way to represent a text link in websites and most hypermedia systems. To provide feedback about the selection of an issue for further information, a checked box appears as a visual feedback to signal that the action was accepted;
- **To support interoperability*,*** considering that the iTV interfaces were designed with a clear reference to the web content being generated as additional content to the video being watched. In fact, the web content is referenced through all interfaces (information and device confirmation, sharing and service finalization interface) suggesting a mental model about the whole application and how it works (**transparency**) and also helping to perceive it as **coherent** (as a whole). As to the web content it also reminds viewers about the original video, and the iTV context of use, considering that the **contextualization** was assured through the use of excerpts from the original video;
- **To support continuity*,*** considering that active interaction strategies, as crossmedia referencing, were used. In fact, in the finalization interface, viewers are asked about which device they want to use in order to access the web content, thus reminding viewers that these devices are connected with and part of the same application. This also helps in the perception of the application as **coherent**, as a whole;
- **To support usability,** considering that the main concern was to provide the service with the more adequate functionalities in each context, through an easy to use and intuitive interface. This was achieved through the use of a coherent navigation structure along interfaces, same graphics and colors, chromatic, numerical and directional keys with visual correspondence on screen (when in iTV), visual feedback of viewers choices, use of traditional navigational (when in the web content), etc;
- **To support flexibility** *and* ***personalization***, considering that in the web content, the excerpts of video used to contextualize viewers were made available starting exactly at the moment of the topic choice and a few seconds

before the moment of the choice in order to have sentences with meaning. As to the web content selected topics, they were organized by order of selection but also with the possibility to organize them by alphabetical order or in a content dependent fashion.

The eiTV design options were implemented in the prototypes and evaluated. This evaluation is presented in the next section.

4.2.3. Evaluation

Both genres prototypes, documentary and CSI series, were evaluated through a similar process: using low and high fidelity prototypes, with the same evaluation method, same number and category of evaluators, etc. However, considering that the documentary was the first to be implemented, it was a simpler version (without the two types and three levels of information as explained in section 4.2.2.2.). The goals, methods and results from the evaluation are presented in the next sections.

4.2.3.1. Evaluating the Low-Fidelity Prototypes

In an early phase, the low-fidelity prototypes were evaluated, more than once (iteratively), in the following contexts:

- **An expert usability evaluation** via heuristics and streamlined cognitive walkthroughs (Lamont, 2003a) was conducted. The group included two HCI experts and one iTV expert;
- **A viewer usability evaluation** through individual evaluation sessions, where viewers followed a task-based script (Annex F) where they were asked to perform tasks that allowed using all the eiTV application functionalities. Simultaneously, the evaluator filled in a specific grid, constructed based on the viewers script (or task list) and took notes on all the aspects related to each specific task (Annex E). This evaluation was conducted with a group of 15 students from ESCE ranging from 20 to 44 years old: 5 from Information Systems Management Degree (ISMD) with more technological literacy, 5 from the Marketing Degree (MKTD) with less technological literacy, and 5 from the Human Resources Management Degree (HRMD) with lower technological literacy. According to Nielsen (1993), the use of 5-8 users in usability tests represents a good relation between the evaluation costs and the number of

usability problems that may be found. That was why we have used 5 viewers' for each category.

- **For both experts and viewers, an affective evaluation** was conducted in order to evaluate the affective dimension, the pleasure associated to the use of the application, which, to some extent, contributed to evaluate User Experience. The tools used were the Self-Assessment Manequin (SAM) to measure affect (Lang & Bradley, 1994) and the HQ scale to measure Hedonic Quality (Hassenzahl *et al*., 2001). Details about these tools and type of evaluation in section 3.4.5.

In order to help understanding the decisions made in the design of high fidelity prototypes, low fidelity prototypes evaluation results were being referred along section 4.2.2. However, they are discussed here in more detail:

In general terms, viewers appreciated the different aspects of the application: functionalities, interfaces, the idea of the application, its utility, etc. Nevertheless, some usability problems were detected in this early evaluation phase, as for instance: the need for a more obvious back button, considering that many of them had difficulties in turning back and needed the evaluator support; some confusion associated with the use of the chromatic buttons in the first context (where they were being used to select topics of interest); small differences in terms of user interfaces were detected, as for e.g. the same button being used for two different actions, etc. From the affective evaluation, using the SAM tool it was possible to perceive that the majority of viewers felt pleasure (70%), arousal (63%) and 'in charge' (63%) while using the prototypes which were good results. The HQ scale, where each pair of adjectives corresponds to opposing adjectives, as good-bad, it is evaluated in a 7 points rating scale. The values obtained in 1, 2 and 3 rating scale were summed and it was possible to obtain the following results from the presented list of adjectives: outstanding (53%), exclusive (60%), impressive (60%), unique (67%), innovative (67%), exciting (60%) and interesting (73%) which were also positive results.

The collected information and opinions helped us to rethink the conceptualized models when evolving to high-fidelity prototypes, namely: the navigation structure which was changed to chromatic buttons instead of using those buttons to select topics; in the two genres, the interfaces were designed differently: the documentary with a maximum of three selectable topics in each sentence and the CSI with a maximum of one selectable topics; the selectable topics were identified with underline in the CSI, and were written in the bottom bar on the documentary; the CSI information was made available in two types (contents and metadata) and three levels (topics, summary and structured); when using information levels 2 and 3, the video pauses in order to allow a better understanding and focus on the written information; excerpts of the original video should be used in the generated web content, in order to improve the contextualization process; in terms of the generated web content try different approaches to the excerpts of video: have them playing and paused when opening the web content, and also have them starting exactly at the moment of the topic choice and a few seconds before the moment of the choice in order to have sentences with meaning; in the web content to have the selected topics organized by order of choice but also with the possibility to organize them alphabetically or in a content dependent fashion.

The evaluation of the achieved high-fidelity prototypes (which design options were described in section 4.2.2.) is presented next.

4.2.3.2. Evaluating the High-Fidelity Prototypes

This evaluation was conducted as in the proposed framework (section 3.4.) based on an empirical evaluation via experimentation in **evaluation sessions**, following a task-based script (Annex F) where viewers were asked to perform tasks that allowed using all the eiTV application functionalities (to assure consistency and get a coherent user experience) and next they were also allowed to freely navigate as they wished, under the evaluator observation. These evaluation sessions were conducted individually, only with the presence of one viewer at a time and the evaluator. The evaluator used a specific observation grid (Annex E), based on the script (or task list), in order to take notes on all the aspects (hesitation, errors, comments, etc.) related to each specific task (section 3.4.4.2.) during the evaluation sessions. These evaluation sessions were recorded. The experimentation took place in a specific room decorated to look like a typical domestic environment, a living room (Figure 46). It was preceded by an explanation of basic features of the application and was followed by a **questionnaire** (Annex G) constructed as recommended on the proposed framework (section 3.4.4.3): based on the well-known USE questionnaire to evaluate usefulness, satisfaction and ease of use (Lund, 2011); on the NASA TLX questionnaire, which allows to evaluate cognitive overload (NASA, n.a.) and questions related to usability heuristics taking into account the crossmedia requirements and design dimensions identified in chapter 3 and summarized in section 4.1.4. The questionnaire comprises questions in order to evaluate each eiTV application functionality, feature and design option in detail (via Likert scale tables, questions with predefined closed answers and open questions for comments and suggestions). Furthermore, at the end of the questionnaire and in relation to the eiTV as a whole, specific tables are used in order to evaluate: usefulness, ease of use, ease of learning, satisfaction and cognitive overload.

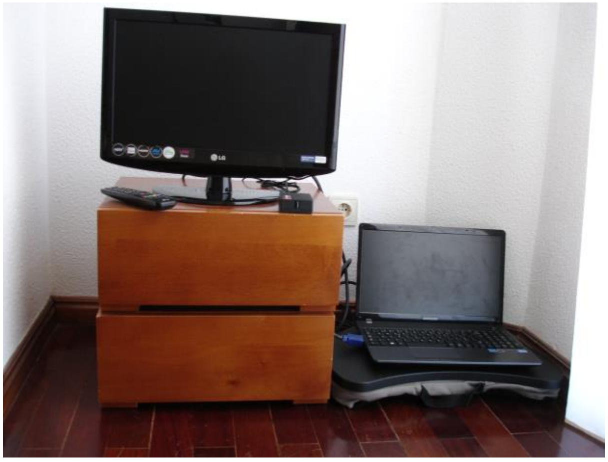


Figure 46. Evaluation Sessions Room

With the questionnaire, we intended to complement the empirical evaluation and the direct observation. This gave us the possibility to check that the answers to the questionnaire were in accordance with the reactions, denoting levels of difficulty or satisfaction that we observed in the viewers' while using the application. After the questionnaire, and a 15 minutes break, viewers were **interviewed** (Annex H) in order to freely express their individual opinions on the prototypes, and later they all participated in 'interaction sessions' or **focus groups** where a social dialog was generated in order to collect rich opinion data.

Evaluation sessions, questionnaires, interviews and focus groups had the participation of 30 persons divided into three groups:

- 10 students, with more technological literacy (ISMD). 5 of them already had participated in the low-fidelity prototypes evaluation. The other 5 were in contact with the application for the first time;
- 10 students, with less technological literacy (MKTD). 5 of them already had participated in the low-fidelity prototypes evaluation. The other 5 were in contact with the application for the first time;
- 10 persons from the general public with lower technological literacy. All of them were in contact with the application for the first time.

A fourth group of experts: 3 experts (2 from HCI and 1 from iTV) only participated in the evaluation sessions in order to provide us direct feedback.

In relation to the documentary prototype, and in brief, all experts considered: the contextualization effective; an advantage connecting different media; the interfaces intuitive and the application useful, but limited and needing more functionalities. As to the 30 viewers, they considered: contextualization effective (83%); an advantage connecting these different media (80%); the interfaces intuitive (80%) and the system useful (77%).

In relation to the CSI prototype, in brief, all experts considered: the contextualization effective; an advantage connecting different media; the interfaces intuitive; the application useful and offering a great potential to more elaborated functionalities. As to the 30 viewers, a sample of the target population, the results are presented next in relation to each research question. As to the evaluation results presented next they do not include the results from the expert group evaluation.

With this evaluation method and the participation of these groups, some of our main research questions were clarified, namely:

RQ1*: Which model interface design and functionalities are adequate in order to: a) Provide an adequate support to create and follow extra web contents? and b) Have interfaces easy to use and understand in each of all devices (usability)?*

At this point, mobile phone interfaces were being developed. From the questions used in order to validate this question, in what refers to iTV and PC (the other devices used), the most important are presented in Table 4 as follows:

Table 4. iTV and PC Interfaces Usability

	Nothing	Little	Average	Much (1)	Very Much (2)	(1)+(2)
Were the iTV interfaces adequate to create the web content?	0%	3%	20%	10%	67%	*77%*
Were the iTV interfaces adequate to conduct you to the web content?	0%	0%	33%	20%	47%	*67%*
Were the iTV interfaces easy to use?	0%	3%	30%	40%	27%	*67%*
Were the iTV interfaces easy to understand?	0%	4%	33%	43%	20%	*63%*
Were the PC interfaces easy to use?	0%	0%	13%	17%	70%	*87%*
Were the PC interfaces easy to understand?	0%	0%	6%	17%	77%	*94%*

The results obtained in relation to the iTV were good considering that viewers were not used to this level of TV interaction. However, it was our belief that we might achieve better results by the improvement of the interfaces and the navigational structure.

Were the iTV interfaces easy to read? In order to test legibility, some changes on brightness and contrast were made (four levels above and below normal values were tested). The results are presented in Table 5 as follows:

Table 5. iTV Interfaces Legibility

	Nothing	Little	Average	Much (1)	Very Much (2)	(1)+(2)
In normal conditions all the interface elements were easy to perceive	0%	10%	27%	20%	43%	*63%*
In lower and higher levels of brightness all the interface elements were easy to perceive	0%	13%	27%	40%	20%	*60%*
In lower and higher conditions of contrast all the interface elements were easy to perceive	0%	17%	33%	40%	10%	*50%*

Although slightly different, these results may indicate that changes in contrast are more disturbing than changes in brightness. As a note, the time of response of the remote control was also adjusted, in order to obtain a time of response similar to a real TV viewing experience.

In what refers to the presentation of the video pausing while in the create functionality (levels 2 and 3), it was the viewers preferred option from low fidelity evaluation and thus it was implemented in high fidelity. Nevertheless, 80% of viewers stated that, probably, they would prefer to have the video playing.

All viewers used the generated web content and evaluated if the interfaces were easy to use and easy to understand with the following results: in relation to the ease of use 33% said much and 43% said very much, meaning that a total of 76% agreed that it was easy to use. When asked if it was easy to understand 33% said much and 47% said very much, meaning that a total of 80% agreed that it was easy to understand. When asked about if they agreed with the level of development of the presented topics: 18% said much and 70% very much meaning that a total of 88% said much and, when asked about the adequacy of the presented information in relation to the selected topics: 23% considered much adequate and 67% very much adequate, meaning that a total of 90% considered it much adequate.

RQ1*: Which model interface design and functionalities are adequate in order to:* ***c)*** *Create personalized web contents appropriate to give sequence and continuity to informal learning opportunities created by the visualization of the video (are they able to contextualize viewers in relation to what they first saw and provide further coherent content)?*

From the questions used to validate this research question, the most important ones were the following two:

- Did the web content contextualization succeed? 27% said much and 53% very much (meaning that a total of 80% said much);
- Were the web contents capable to give continuity to the program? 20% said much and 57% very much (a total of 77% said much).

As to the *presentation of topics*, 73% preferred the selection order, 17% the alphabetical order and 10% preferred the logical order, indicating that a good choice would be to have the selection order as the default choice, and providing the possibility to change order, thus providing them with flexibility.

As to the use of the *video excerpts to contextualize the content* in relation to the original TV program: 90% preferred the video playing and 10% preferred the video paused. Video playing will probably be the best default choice with the control to pause and play as the viewer wishes. This aligns with the continuity principle to provide more immersive and engaging user experiences, when coming from iTV, especially if users do not want to engage in more deep reflective cognitive modes, at least in a first contact.

As to the *video excerpts selection*: 13% preferred that the videos start at the time of selection, while 87% preferred the use of a previous video position in order to include a complete sentence in the video and improve the context.

As to viewers opinion about using videos for contextualize, 87% said that the contextualization succeeded.

***RQ2**: Is there a real advantage in connecting these devices in order to generate additional web content information to a video?*

20% of the tested population said much and 63% very much, meaning that a total of 83% said much. As main advantages (they could indicate more than one from a pre-defined list, available in question 7.1. from the questionnaire presented in Annex G): 90% indicated the possibility to have extra information about a program viewed on TV; 93% the mobility (in terms of the possibility to see the web content through mobile phone anytime, anywhere); 83% the novelty of the system, and 77% the connection of the TV with other devices.

***RQ3**: What are the preferred interface designs for the relevant cognitive modes and needs in each scenario? Along the several options and functionalities, which interfaces work best to support the different cognitive modes (experiential and reflective) and levels of attention?*

When selecting topics to generate the web content, 79% of the viewers preferred the *level 1* information interface in this evaluation context. However this result should be analyzed more carefully because levels 2 and 3 paused the video, which was an option taken based on the first low-fidelity evaluation process. In fact, those evaluation groups' opinion was that the video should be paused or otherwise: "viewers' would not be able to follow the video", "might skip new link opportunities while reading the presented content", and "they would not have time to reflect about the presented content". Thus, the prototypes were not implemented with the possibility to use information levels 2 and 3 with the video playing. On the other hand, the high-fidelity prototypes evaluation groups stated that pausing the video is not a good option, since they can be more interested in following the action while making the additional choices. Thus, and since we got different opinions in the two phases, we concluded that both options have perceived advantages and disadvantages, and that the low-fidelity prototypes do not provide a rich enough environment for a realistic evaluation of the interaction with dynamic media like video. In future prototypes and evaluations, viewers will be given the opportunity to change between video pausing or playing while on information levels 2 and 3, with the default being play (maintaining current status and thus less disruptive), or the user preference if stated (maintaining control in the viewer).

As to the *overlaid* and *embedded* design options, in both information levels 2 and 3, 79% of the viewers preferred the embedded option, although not exactly the same viewers, two of them changed their preferences. Overlay is less intrusive for TV viewing, especially when there is not too much info, while embedded is less intrusive for information reading. Results align with this tendency to change the focus of interest from TV to additional info along information levels.

RQ4*: What other functionalities would viewers like to have in this kind of crossmedia environment, capable to generate extra web content to video?*

Only three subjects provided individual feedback on this aspect. Two suggested the provision of synchronous communication (chats) and one suggested the possibility to generate web contents from the PC considering that he was used to watching movies and TV from there. Being a new type of application, it is understandable that most viewers did not have clear ideas about future functionalities for now. Meanwhile, it is our job to devise some. As such, some ideas were launched for discussion during the focus group session and the results were as follows: being able to generate the web contents from any device 77% (23 out of 30 liked the idea); being able to register in order to access their own eiTV private area 73% (22 out of 30); have a menu-based style navigation with different functionalities 67% (20 out of 30) and to have a search functionality to find all generated web contents 60% (18 out of 30).

RQ5*: Are the different devices (with different characteristics and thus different possibilities) as part of an ecosystem (in order to have an identical model and functionalities available across devices) easily adopted by viewers?*

At this point, mobile phone interfaces were yet being developed, so they were not evaluated. As to iTV and PC, they were used as complementary an in a linear mode which means that, at this time, a 'real' ecosystem was not yet developed. However, these devices, which have different characteristics, were used in order to complement each other and, from the evaluation process, we perceived that the use of iTV and PC, as part of a sole application were appreciated and would be easily adopted.

RQ6*: Were the proposed frameworks, for crossmedia and iTV, adequate and efficient?*

Considering that the design and use of the eiTV application was conducted following the directions identified on the conceptual framework for crossmedia (chapter 3) and that the achieved results were very promising we have reasons to believe that we were capable to identify critical points and possible solutions to the design of iTV applications in this context. The same applies to the iTV proposed framework (section 3.2.4.1.).

Note that more specific learning aspect of the application were not tested (if viewers are really capable to learn through the web contents). This type of evaluation requires different tests and would be dependent on the actual content being provided, thus not within the scope of this work.

Concluding, it was possible to perceive a considerable high enthusiasm from the group of experts and the groups of viewers. From the observed reactions, it was possible to foresee the success of this type of crossmedia application and to see how easy it was for them to use the three information levels interfaces, in spite of preferring level 1. In fact, when not asked to use a specific information level, level 1 or 2 were always chosen, although it should be noted that this was not a completely realistic scenario in terms of viewers' intrinsic motivation to further navigate the information. As to the group of people with less technological literacy, the application was considered to be very easy to use. In spite of not having exactly the same expertise, they showed an 'open mind' towards the use of this kind of new applications and technologies. In fact, and in spite of their initial difficulties, they used the prototype with higher facility than expected and, surprisingly, 70% of them said that they were interested in continuing to use this type of services (mainly in level 1) and recommending it to friends. As to the other groups: 90% of students, and 100% of experts, were interested in continuing to use this type of services, and 100% (students and experts) would recommend it to friends.

4.2.4. Discussion

Following the directions identified in the conceptual frameworks proposed in chapter 3, a study exploring the design and use of the eiTV application was conducted. The application is capable of creating, from iTV, crossmedia personalized web contents, as additional information, in order to give an answer to the learning opportunities created by the use of iTV, in informal learning contexts. Several low and high fidelity-prototypes with different interaction proposals where designed, developed and evaluated. From those tests, it was possible to conclude that the application was considered: very appealing for the experts and the groups of students with high and less technological literacy and very interesting to the group with lower technological literacy. In general, the majority of the viewers considered that it is an advantage to connect these media, the interfaces are easy to understand, the web content is suitable to help contextualizing them in relation to the iTV program, and providing continuity to it with smooth transitions between the different technologies tested. It is our belief that the presented study provided a contribute to addressing the identified research and design challenges identified in chapters 1 and 3, by providing new insights on how to design crossmedia applications in this context.

It was decided that the prototypes needed to be redesigned, and re-evaluated, to accommodate the directions and suggestions raised in these evaluations and from our own insights. Directions for further research include exploring: the video playing, as default and as an option, in the interface for information levels 2 and 3; a menu based navigational structure common to all the devices, and making it possible to generate web contents (departure point) from all the devices and to access the generated web contents (arrival point) from all the devices, meaning an enhanced conceptual model. New functionalities will be also researched in the direction of a more powerful and flexible crossmedia environment.

4.3. eiTV Second Generation: Going Beyond iTV Video in the Cloud

In conceptual terms the shift to the second generation was based on a ‘beyond iTV’ concept as well as in the appropriateness of a portal instead of an isolated application. Thus, we may say that the word behind this generation is ‘***CLOUD’***. The paradigm changed due to technological and social factors. Video can be watched anytime, anywhere, from different types of devices. Each device (TV, computer and mobile device) may be used to watch the video, create the web content and access it (devices were used in a **redundant** way). This section presents the design, prototyping and evaluation of this eiTV second generation.

4.3.1. Analysis and Design

As recommended, a UCD approach for the eiTV application design was followed. The options made in terms of design are explained in this section.

4.3.1.1. Conceptual Model

The first generation eiTV application generated, via iTV (the only departure point), personalized web contents related to the iTV program or video being watched, to be further accessed and explored from iTV, PC or mobile devices (three arrival points), depending on the scenario and context of use. It has been redesigned to illustrate and explore the underlying crossmedia paradigm, based on cognitive and affective aspects that influence user experience. It was extended to go beyond iTV and allow the initial interaction to be done with videos from different devices (iTV, PC and mobile phones as departure points), and enhanced features. eiTV was redesigned and extended, based on the evaluation of previous versions (Prata *et al*., 2004a; 2004b; 2006; 2007; 2010a; 2010b; 2010c) and additional research to present broader possibilities, an improved interface usability due to the flexible and simplified navigational model, and new functionalities or options (Home, Webcontent, Create, Search, Share and Profile). The application works as a portal, allowing viewers to access their work area independently of the device being used. Any interaction to the work area will be stored independently of the device in use, and will be visible in the next access through any device as is common in client-server applications.

Concluding, now, all three devices can be both departure and arrival points and the navigation model evolved to a portal (accessible from any device) with six main functionalities or options: Home, Webcontent, Create, Share, Search and Profile. These functionalities are relevant considering that viewers no longer want to be passive. They want a more active role, to collaborate and to create. In this context, it is acceptable to say that consumers have turned into active producers, a role that becomes a true possibility inside a portal with these functionalities. At any time, and from any device, through these functionalities, viewers may create, search and share web contents and videos.

4.3.1.2. Application Architecture

A client-server architecture was adopted for the eiTV application (see Figure 47). As on eiTV first generation, the server stores a database of the: information modules delivered with the TV program (in order to serve as material to create the web contents); TV content meta information; viewers profiles and the specific templates to be used for each device. These templates are responsible for formatting the information to be presented to the viewer, and the application selects them, essentially, based on the type of the access device and the viewer's profile, in order to personalize the application. The server also stores the web content generated by the application and the interactive applications, in order to choose topics of interest, share contents, etc.

As previously, the web contents are constructed dynamically, based on the viewers choices and profiles, with information from two different sources:

information modules and web links. These modules will be complemented with information from reliable websites related with selected topics. The group of links will be made available in addition to the web content, usually at the bottom.

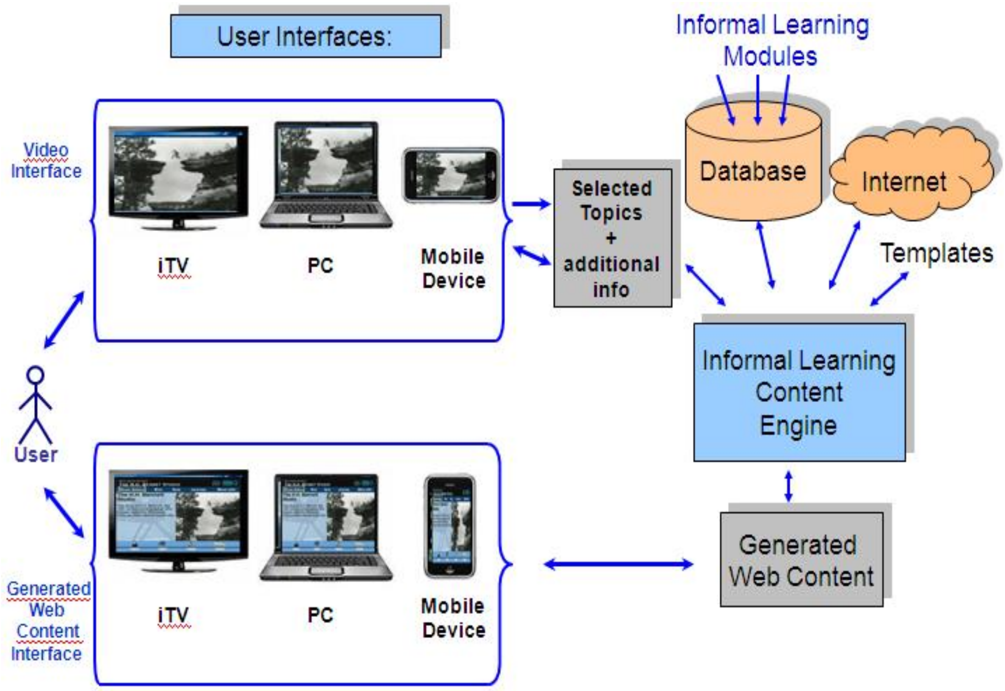


Figure 47. eiTV Second Generation Architecture

eiTV, which started as a group of separate modules (Prata *et al*., 2012), was changed to a unique portal aggregator of all the functionalities which may be accessed from any of the mentioned devices to work as a true ‘ecosystem of devices’. Through the portal, we may: generate web contents; see, edit and share web contents, upload files, change profile, etc.

If eiTV viewers generate a web content which they decide to share with friends, two things may happen: some friends also have the eiTV application (this means having an account on the eiTV application service) and some do not. All of them will be able to access the web content by following a link. This means that everyone may access web contents generated by eiTV, a characteristic that provides **flexibility** to the application.

First prototypes explored the iTV and PC interfaces and were based only on the CSI series (Prata et al. 2010a; 2010b; 2010c), while mobile devices were receiving increasing attention in our research (Prata & Chambel, 2011a; 2011b).

4.3.2. Prototyping

As in the first generation, this section is mainly dedicated to the description of high fidelity prototypes, and to justify some design choices, low fidelity prototypes evaluation results are also mentioned along the text. The evaluation method was the same adopted for the first generation low fidelity prototypes. As to the participants, the group of 15 students was maintained while the experts group was increased with two iTV experts. When the first sketches were ready, the evaluation started and from this evaluation, in general, it was possible to perceive that they appreciated the different aspects of the application: the concept of a portal, its utility, functionalities, interfaces, etc. However, some preferences and usability problems were identified and are presented in the next section to justify some high fidelity prototype choices.

As in first generation, these prototypes were developed using the following list of programing languages and software: ActionScript for the application, PHP to the server side, MySQL to the database, HTML/JavaScript/CSS to the web content, Flash to the application, Eclipse to the server and web page, PhpMyAdmin to the database configuration and Cpanel to the server configuration. In these prototypes users select what, when and to which device the UI should be changed. Thus being this is a user **trigger activation type** and as to the **timing** dimension, the migration occurs **immediately** after being triggered by the user.

As to the design of the high fidelity prototypes, fundamental aspects are addressed, as the flexible navigational model adopted, the eiTV extended functionalities, and the design options underlying the whole application. In these prototypes versions, the access to interfaces was available through the PC and TV in high fidelity prototypes, and in low fidelity prototypes through mobile phones. The prototypes were implemented solely on the CSI series.

4.3.2.1. Flexible Navigational Model

As to the navigational model and information organization, the previous linear model, based on sequential screens (Prata *et al*. 2012) was replaced by a menu style navigation, which provides **viewers** with much more **control** over their choices, considering that all the functionalities may be accessed at any moment, directly through the main functionalities menu (presented in Figure

48). When using eiTV, all functionalities or options (Home, Webcontent, Create, Search, Share and Profile) may be accessed by using directional keys and the OK button or, in the case of the main functionalities (Create, Search, Share and Profile) and when using the remote, just by using chromatic keys as shortcuts: Create (red: the first letter is in red to provide a visual clue about the color to use, the same happening for the remaining options), Search (green), Share (yellow) and Profile (blue). When using PC or mobile devices, chromatic keys shortcuts are not available, but the use of the same colors in the text helps to create a sense of **unity** and **coherence** within the whole application.

Figure 48. Functionalities/Options Menu

In general, the navigation model was designed to improve: 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 viewers easily perceive the application as a whole unit; **transparency** considering that viewers easily understand how the application works; **adaptability** since the application UIs easily adapt to the context of use which includes user, platform and environment; **synergic use** considering that what is possible to achieve with the reunion of devices is higher than what would be achieved through their individual use; efficiency when dealing with **heterogeneity** taking into account that different media and devices are being used; **crossmedia interaction continuity** (to support a good **UI Migration**) through different devices and the **interaction consistency** considering that it becomes easier to reuse viewers interaction knowledge, and overall **usability**. Due to its **flexibility,** this model is also more adapted to changes **in cognition modes,** levels of **attention, goals, needs** and technological **literacy** (as explained along the following sections in relation to each specific functionality and feature)**.** As to the interfaces they are simple, have a minimalist aesthetic and were designed based on each device characteristics and the guidelines referred to in section 3.2.4 which is in accordance with Mayer (2001) **coherence principle** which states that it is easier to learn when superfluous material is excluded.

4.3.2.2. Extended eiTV Functionalities

The main eiTV features and functionalities are described next:

4.3.2.2.1. Home

The Home functionality was improved. It is separated from the profile and allows to login to the eiTV, change viewer and create new viewers (Figure 49). This functionality considers all the possibilities (inserting a wrong PIN, forgetting the PIN, the need to create a new account, etc.). These possibilities were identified mainly through the evaluation of low fidelity prototypes, especially with the collaboration of the most technological literate, considering that they are very used to creating and using new accounts. Usually, viewers' do not like the need to authenticate, but some studies (Jesus, 2009) and experiences have shown that when they use personal information (as on e-mail, Facebook, etc.) they do not mind to do so and even prefer the sense of security that is provided. 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 (see Figure 49-a), 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. In order to provide viewers with **flexibility**, and to support frequent viewers, this information may be stored on the device being used.

This functionality features are important in order to accommodate viewers' needs in terms of **personalization**, **security, adaptability** and **flexibility**.

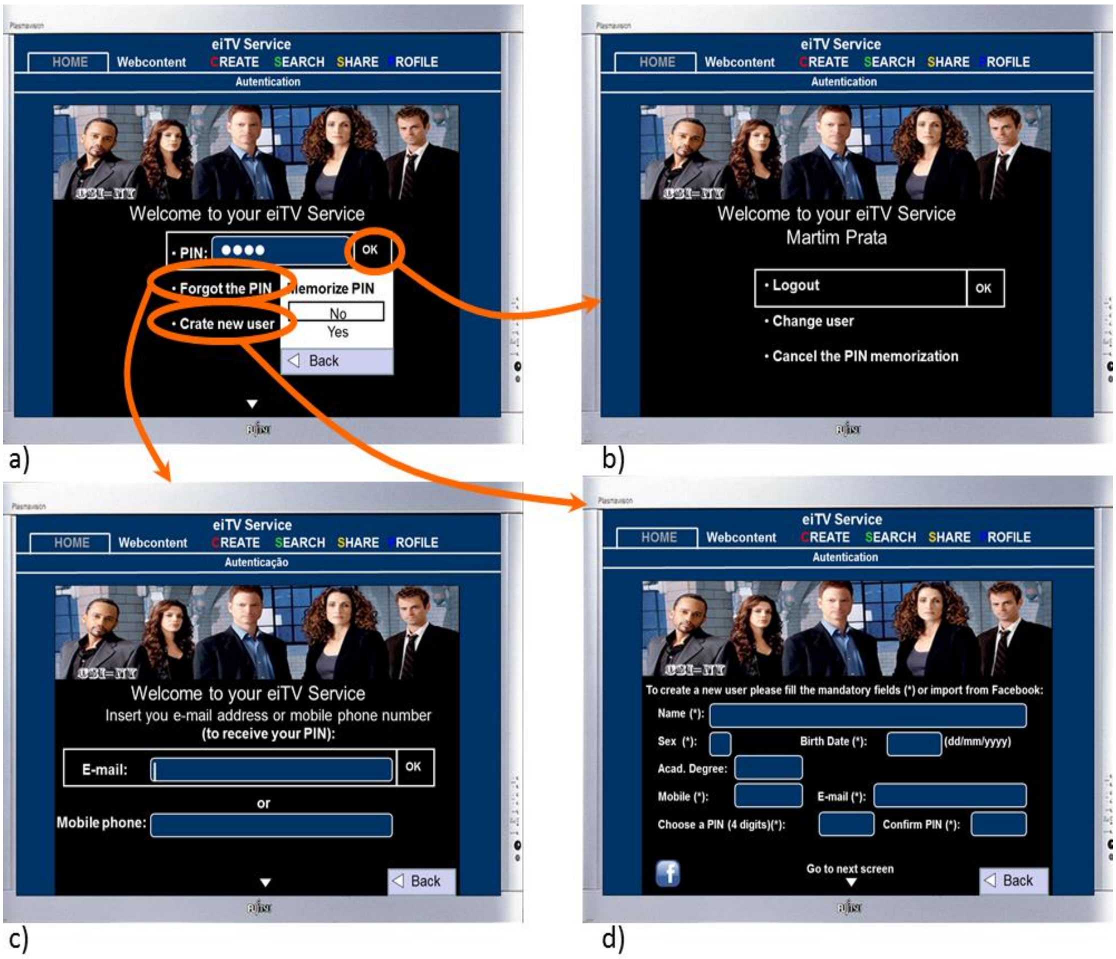


Figure 49. Home Functionality

a) Entering a PIN from iTV; b) Interface after a correct PIN; c) Interface to recover a forgotten PIN; d) Interface to create a new user account.

4.3.2.2.2. Webcontent

The Webcontent option allows viewers to access all the generated web contents. The complete list is organized as follows: by the program names which are organized by alphabetical order, program series and episode number (see Figure 50-a). Below each program name, series and episode, the web contents will appear organized from the most recently generated to the oldest. From the different proposed organization criteria, this was the preferred one in the low fidelity prototypes (80%) and thus it was implemented (the other two proposed organization criteria were: 1) independently of the program name, organize the web contents simply from the most recent to the oldest and 2) The list was organized by program name alphabetically and inside each program from the most recent to the oldest). As to each web content from the list: it is possible to follow the link to access it, get information about its creation date, the device used to create it, the last actualization date and the synopsis (Figure 50-c), to share it (Figure 50-d) and to delete it. When several web contents are generated to the same program, a *merge* option is made available in order to generate a unique web content as a compilation of all the others. These options were designed to provide **flexibility**, **user control**, improve **UX** and to take advantage on viewers' previous knowledge and **experience.**

Figure 50. Webcontent Functionality

a) Interface with the list of available Web contents. From there, it is possible to access the other 3 interfaces; b) Interface to see the Web content; c) Interface to see Web content Info; d) Interface to share the Web content.

4.3.2.2.3. Create and Update

The Create central functionality allows users to select topics of interest for further information while watching videos. As in the previous version, the information available about the TV program differs in focus and scope (TV content and TV Meta-info). Both types of information were made available on the three proposed *levels of information* (1-Topics; 2-Summary and 3-

Structured), from less to more informative, and thus with different levels of detail.

At any moment, the viewer is able to change between levels of information by pressing button 1, 2 or 3 or by using the directional keys. Thus, the eiTV navigation is flexible to viewers with different preferences and levels of experience. It was decided to maintain the 3 levels of information, with embedded and overlaid options in levels 2 and 3 (see Figure 51), since it was concluded from the first generation prototypes that they play an important role to accommodate viewers' changes in **cognition modes**, levels of **attention**, **goals**, **needs** and interaction **preferences**. On low fidelity prototypes, different interfaces proposals were tested, especially in terms of **usability** (one of the interfaces comprised more options in the bottom navigation bar, as for e.g. labels for 1, 2 and 3 instead of only numbers, as used in first generation prototypes; another presented less options in the navigation bar but some were on screen; another presented the buttons in a different order, etc.). The preferred one (73%) was used in the high-fidelity prototype. As to the Create functionality, we present next the new features in the current eiTV version (including updating and editing) and the aspects covered in the creation that influence the contextualization when accessing the Web Content.

- **Topics Selection: Video Keeps on Playing?** For both information levels 2 and 3, which require a higher level of user attention, two options were designed and implemented: The *video playing* (with the pause button available) and the *video paused* (with the play button available) in order to understand viewers' preferences in each situation. In the first generation, these two options were already tested on low fidelity prototypes where viewers preferred the option with the video paused, which was the one implemented on the first generation high fidelity prototypes. However, on the first generation high fidelity prototypes evaluation, 80% of viewers stated that they would probably prefer to have the video playing. Low fidelity prototypes, in spite of being very useful in many situations, they do not provide a rich enough environment for a realistic evaluation of the interaction with dynamic media like video. Thus it was decided to repeat the experience, with both options available now in high fidelity prototypes. Both options are **flexible**, prepared to accommodate changes in

cognition modes and prepared to assure **continuity** (through the play option when the video is paused).

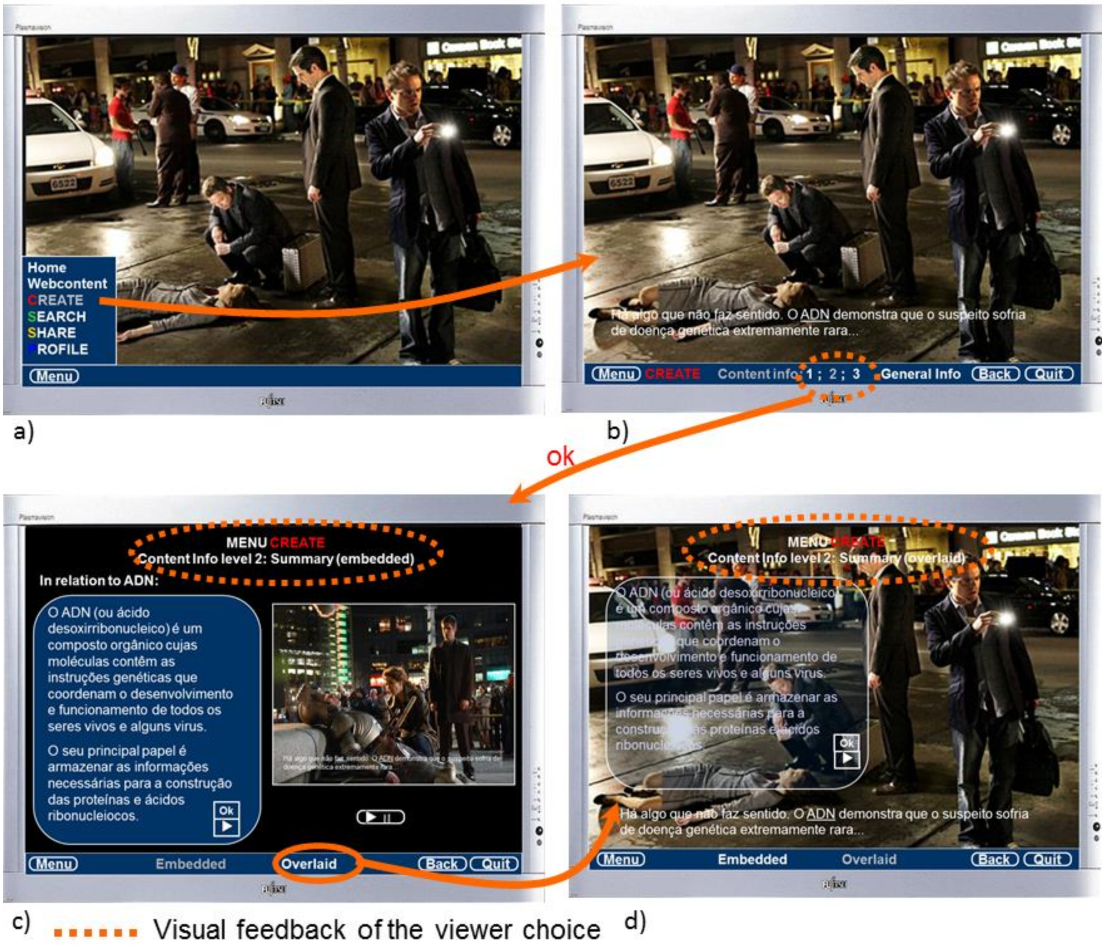


Figure 51. Create Functionality (Interfaces for information level 2)

a) Main menu where the create functionality was chosen; b) Interface where information level 2 was chosen; c) The topic DNA was selected and the related information was presented embedded on screen; d) Information about DNA being presented overlaid on screen.

- **Creating Content from Videos on the PC***.* The Create functionality is also available *through the PC*. The difference is that on iTV, viewers' choose the program from the BOX or from a TV channel. On the PC, viewers have to choose a video that needs to be previously uploaded to the 'portal' or follow a video link. This feature greatly increases the **flexibility** and **consistency** of eiTV and provides the application with **adaptability** considering that the UI adapts in order to use the same features from different devices.
- **WebContent: When I Watch the Same Video**. If a viewer watches a specific program several times, and every time decides to generate a web

content, all will be stored in the ‘portal' in a specific category named **Webcontents**. As previously mentioned, program names are organized by alphabetical order, program series and episode number, and each web content allows to access information related to it, may be shared and deleted (see Figure 50). Each web content name has a link to the web content. When several web contents were generated to the same program, a *merge* option is made available. These options were designed to provide **flexibility**, **user control, personalization** and to take advantage of viewers' previous knowledge and **experience.**

- **Webcontent: My Input***.* The My Input is a specific place (a tab) within the generated web content where the manually uploaded information is stored (text, pictures, videos, sound, etc.). This means that after generating a web content at any moment in time viewers may upload information to that web content which will be stored in this specific tab.

Each web content is organized as follows. The left side menu contains all the topics selected by the viewer, presented by the order of selection in the TV program, to improve contextualization, but the viewer may choose to see them by alphabetical or logical (content dependent) order (see Figure 52-a). Sub-categories of the topics are presented in the top menu. The main difference in this generation is that this web content is presented inside a ‘portal' which also has all the other functionalities: Home, Create, Search, Share and Profile. The Search functionality also allows the upload of information to a specific web content. Thus, below the selected topics presented on the left side menu, there is the ‘My input' place (see Figure 52-b) were all the information uploaded by the viewer is stored. This option was designed to take advantage of each **device characteristics** considering that, it is prepared to accommodate mobile device characteristics (in fact, from mobile devices it is very easy to create videos, take pictures, record sound files, etc. With this option the application is prepared to store and associate that extra information to a specific web content). This option also provides **flexibility** and **personalization.**

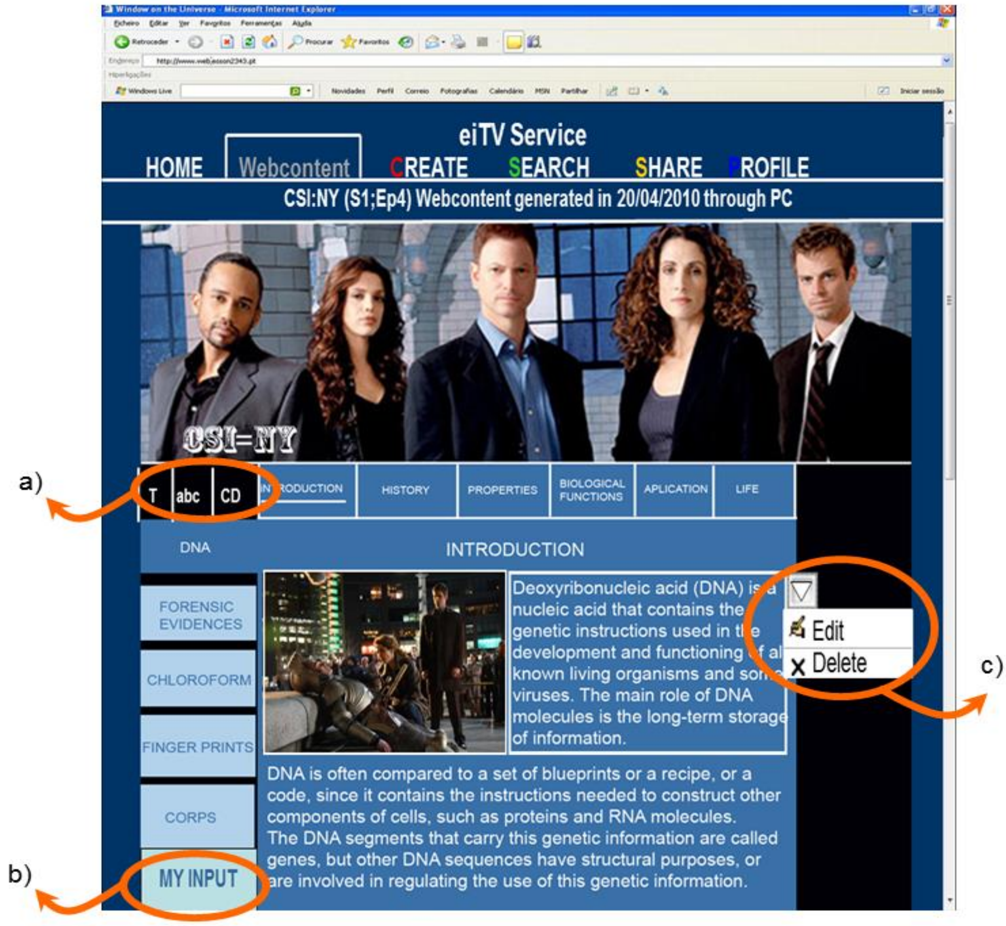


Figure 52. Webcontent Organization

a) Topics organized by: 'T' for topics order, 'abc' for alphabetical order and 'CD' for content dependent order; b) My Input place or tab; c) Option to edit or delete a paragraph within a topic.

- **WebContent: Editing.** Each web content has the possibility to be edited. This edition ranges from *editing* existent information, *uploading* textual information (if through the TV set) or textual information and files (if through PC or mobile phones) to *delete* the web content, a topic from the web content, a category from a specific topic or even just a simple paragraph (see Figure 52-c). This option was designed to provide viewers with **flexibility**, **control**, **autonomy**, **consistent interaction** and to take advantage of each **device characteristics** and **experience.**

- **WebContent: Contextualizing Video or Image Continuity** and **contextualization** (exemplified in Figure 53) are some of the most important characteristics to assure crossmedia integration. Thus, some tests already made with previous versions were now repeated and extended as explained next:

Contextualization was supported via the use of three different options. Options 1 and 2 rely on 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, viewers 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); option 3 is a new option that relies on the presentation of an image of the video frame at the moment of the topic selection. With these three options, we expected to gain a better understanding of the efficacy and the preferences to help creating a smooth transition with a good **contextualization**. When these tests were first carried out on the eiTV application (first generation high fidelity prototypes) the results were the following: as to the use of the *video excerpts to contextualize the content* in relation to the original TV program: 90% preferred the video playing and 10% preferred the video paused. However, due to the relevance of this dimension a new approach, through option 3, was tested. Thus, options 1 and 2 were repeated in order to understand if viewers' preferences would change in the presence of this third option.

- **WebContent: Contextualizing Video Sound. I**n what concerns the **video excerpt selection**, used on the web content with the continuity and contextualization purpose, two options were made available, and already tested with first generation prototypes: 1) to have the videos beginning at the selection time; 2) to begin in a previous position to include a consistent dialog and context. On the first generation prototypes viewers preferred option was 2), 87% against 13%. Thus, considering that no other option was introduced or needed to be tested, this choice was adopted in this prototype.

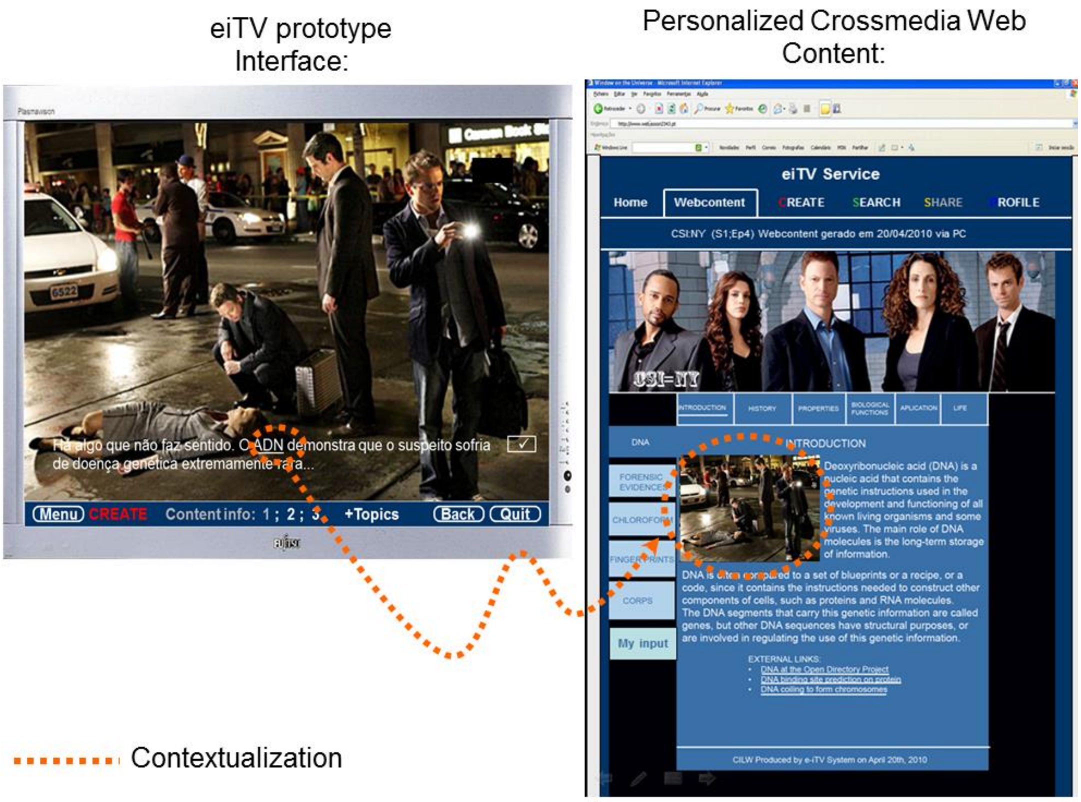


Figure 53. eiTV: contextualization in crossmedia navigation

4.3.2.2.4. Search

The Search functionality is new. This functionality allows searching videos based on different video criteria and application criteria. As to the video criteria: title, actor name, director, film shooting place and subject are available. If none of these options answer viewers' needs, they may search by desired keywords (Figure 54-a). Searching videos based on application criteria is also possible and the proposed options are: video with, or without, web content already generated. The found videos are presented in a table which lets 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 (Figure 54-b). By choosing one of these videos, viewers will be presented with the video synopsis at the left side and the video playing (but it may be paused) at the right side (Figure 54-c). From there, they may choose between watching the video, editing the web content (if there is one) (Figure 54-d) or simply going back.

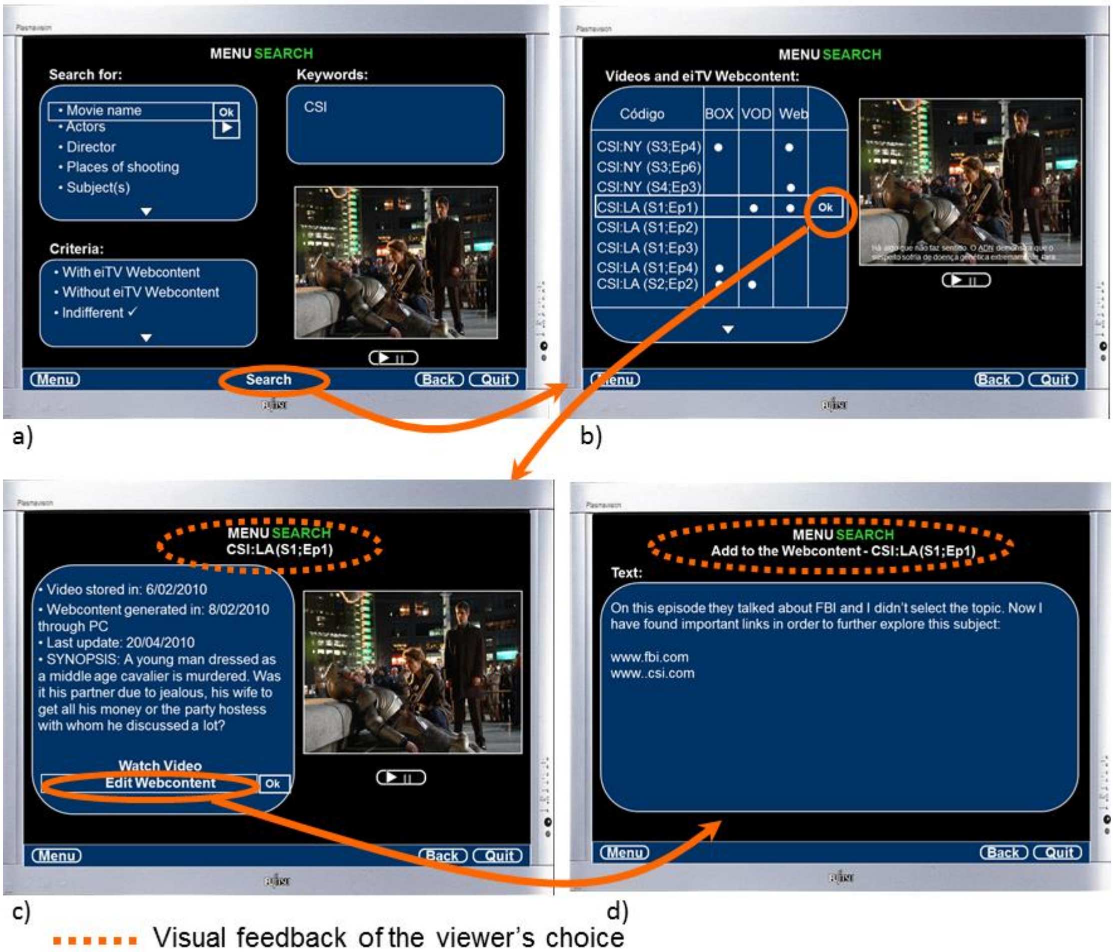


Figure 54. Search functionality Interface

a) Search a video using the keyword: CSI; b) List of videos found about CSI; c) Interface after choosing one of the found videos; d) Editing the web content associated to the chosen video by adding some text.

With this functionality, **flexibility**, **continuity** and **adaptability** were improved and the application is prepared for different **experience** and **cognitive modes** considering that the search functionality comprises options with different levels of difficulty and intrusiveness. It was designed in order to take advantage on previous experience, considering that the search items are somehow similar to those presented through the VOD (Video on Demand) main TV cable providers.

In what refers to the low fidelity prototypes evaluation, this functionality was the one which presented more usability problems and thus needed more iterations in order to become ready to implement. It was also during the low fidelity evaluation that the option of having the video playing (but with the pause option) was suggested by 67% of viewers. They considered that this would improve: the recognition of the video, errors prevention and, with the pause, the flexibility of the application. Low fidelity prototypes are not very adequate to test dynamic media, but considering that 10 of these viewers already participated in first generation low and high prototypes evaluation, they acquired some experience that allowed making up for this limitation in this evaluation.

4.3.2.2.5. Share

The Share functionality changed. When viewers login, this functionality is not immediately available (thus it appears in a different and dimmed color – restriction usability principle (Norman, 2002). This functionality will be activated only after viewers accessed the Create or Search functionalities when there will be something to share (see Figure 50-d). When available, the Share functionality allows sharing the generated web content, or retrieved video (with or without web content), with viewer’s contacts. In fact, this share functionality does not send web contents, it just sends, to the viewer friends, the link to the web content. However, to those who receive the link, it is possible to copy the web content to their own eiTV application area. For this functionality, **flexibility** and **error prevention** were improved considering that this functionality is made available under specific conditions, namely, after creating or searching a web content.

4.3.2.2.6. User Profile

The User **Profile** functionality was extended to improve **personalization**: new is the option to upload viewers personal data from their social network; validate the input information and present improved error messages (see Figure 49-d). Considering that viewers do not like to input too much written information, the number of items to fill in were 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** and **personalization.** As to the improved options, they will help viewers with less **technological literacy**.

4.3.2.3. Design Options Underlying the Whole Application

In general terms the design options underlying the whole application were taken in order to provide the application with:

- **Consistency and Unity** - all interfaces were designed to 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 unit, independently of the device being used: **coherent user experience**. In particular, the same buttons are always used to the same actions and appear in the same place, making easier the navigation understanding across devices through predictability and helping to avoid errors: **consistency, continuity** and error prevention. Viewers' are always aware that they may access their eiTV application through different devices because when they create web contents they are notified via e-mail (that may be read through PC or mobile, reminding viewers that they may use these devices to follow the link), and via sms (reminding viewers that they may follow the link through the mobile). Some interfaces use crossmedia referencing considering that they have the information written on screen, as for e.g. the profile where viewers are presented with the list of available options to be informed about the link location: e-mail, sms or both. This is important in order to increase the sense of **unity** of the application that should be conceptually understood as an 'ecosystem of devices'.
- **Flexibility and efficiency of use** - includes options to the more and the less experienced viewers and is flexible and adapted to changes in cognition modes, level of attention and viewers interests, needs and goals: 1) colors and numbers were used as shortcuts and the menu may be used or not in order to select options; 2) different levels of interaction were designed to be chosen by viewers. These levels of interaction are needed in order to accommodate: changes in interests, goals, needs and cognitive and attention levels; changes in terms of social context of TV viewing (it may be an individual or group experience, and a group experience comprises different individuals with different needs). For these group situations, for e.g., the interaction designed on the level 1 information (topics) does not interfere with the TV viewing experience of those that are not using the application.
- **Aesthetical and minimalist design** - screens were simplified - 1) the navigation instructions were erased from almost all the screens, just kept on the first ones (inside the Home functionality and next to the login feature). It was assumed that, after that first contact, viewers would be able to remember them, especially considering that a common and familiar navigational structure was

adopted; 2) by having a minimum number of different elements on screen (icons, active areas and redundant information) without compromising the application understanding; 3) the interface uses neutral colors (like white and grey) and blue, always with the same sans-serif font, a letter pitch of 18 and anti-aliasing treatment, for improved **legibility** and **usability**.

A research conducted by *Obrist et al.* (2010) in order to develop an electronic program guide (EPG) running on the TV, PC and mobile phone, showed that viewers prefer a *reduced number* of navigation keys and a unified User Interface (UI) with the same functionalities across devices. Thus it was decided to adopt this strategy. The interfaces were unified across devices and the number of navigation keys (buttons) were minimized: four arrow keys; OK; Back; Quit; Menu and Play/Pause. Additional shortcut keys: four chromatic (red, green, yellow, and blue, only functional through iTV); and numbers 1, 2 and 3, to allow faster access to **more experienced users, flexibility** and increased **usability**. The keys were carefully chosen in order to be as close as possible, thus avoiding viewers need to look at the TV remote every time they need to interact.

- **Simplicity, Visibility and Feedback** - iTV Viewers are used to simple commands and quick answers as, for instance, changing channel. This was taken into account in the design. Instead of graphical buttons, which sometimes are not very intuitive for viewers, the interface was designed with written buttons in order to provide visibility. Written buttons were the preferred option (80%) from low fidelity prototypes evaluation, where viewers were presented with interfaces with the same functionalities and only different in terms of buttons: one interface had graphical buttons while the other one had written buttons. The written buttons were implemented in order to keep viewers aware of their location due to visual clues, and to provide visual feedback in order to let viewers' know that their actions were understood by the application. This is very useful, especially for less experienced viewers. This type of feedback, which assures **continuity** (considering that the visual feedback about viewers location help in creating a sense of continuity) and **consistent interaction,** helps to **prevent errors**, understand the application and support viewers' change of mind, also providing them with increased control, **usability** and **flexibility**.

- **User Control and Freedom** - by presenting the go back button, and the quit button, independently of viewers' location. However, for safety reasons and also in order to **prevent errors**, the quit button always needs a confirmation. These characteristic also help in accommodating viewers changes of interest, **attention** levels and in the prevention and recovery from errors**.**
- **Error Prevention** - to minimize the possibility of errors, several strategies were used, as for instance, eliminate error-prone conditions (ex: inactive buttons were dimed, some confirmation options were made available, etc.). Anyway, a few error messages were also created in a way that they could be clearly understood.

On the first generation prototypes, viewers had the possibility to define which device they wanted to use in order to watch the generated web content, right before generating the web content (Figure 42) or when defining their interaction preferences (Figure 37). This option was removed from the application, considering that the web content is simply generated and the interface is automatically adapted, taking into account the device that is being used to access it. As to the "enter" word presented on screen to remind that the interaction mode was available (Figure 38-a) it was also no longer implemented, considering that now a portal is used and accessed through a login feature in order to be able to interact.

4.3.3. Evaluation

Just like it happened in the first generation, prototypes were evaluated through low and high fidelity prototypes and using the same evaluation framework as presented next.

4.3.3.1. Evaluating the Low-Fidelity Prototypes

The low fidelity prototypes were evaluated through: **expert usability evaluation** (this time with 5 experts: the same group from the first generation evaluation and 2 more iTV experts) and a **viewer usability evaluation** (with the group of 15 students that participated on the first generation low fidelity prototypes). The script of tasks used is presented in Annex I. An **affective evaluation** (with both experts and viewers groups) was also conducted. In order to improve clarity, some results obtained were already mentioned in section 4.3.2. in order to justify design choices for the high fidelity prototypes. Nevertheless, the more important ones are presented next:

Some preferences and usability problems were identified in this early evaluation phase, as for instance:

- The preference for text versus buttons on the navigation bar (at the bottom) by almost all the participants (80%). They argued that the presented graphical buttons were adequate but that to see the word written would allow them to be less focused on navigation details and thus prevent errors;
- Some confusion associated with the use of the search functionality. It was not clear that users could search videos, either with or without any web content created. With some adjustments in terms of interface and navigation structure, and several iterations, a clear solution was found and implemented on high fidelity prototypes. This functionality was new, what also justifies their initial difficulties;
- A preference for having the video playing when the viewer selects one of the found videos among the search results was demonstrated by 67% of viewers. They considered that this would improve: the recognition of the video, errors prevention and, with the pause button, the flexibility of the application;
- The Webcontent functionality allows viewers to access all the generated webcontents. From the different proposed organization criteria, the preferred (80%) and implemented was: organize webcontents by the program names, alphabetical order, program series, episode number and from the most recent to the oldest. Two other organization criteria were proposed: 1) independently of the program name, from the most recent to the oldest and 2) the list organized by program name alphabetically and inside each program from the most recent to the oldest;
- As to the create functionality and the information types and levels, different interfaces were tested, especially in terms of usability (one of the interfaces presented more options in the button navigation bar, another presented less options in the navigation bar and some in the screen, another presented the buttons in a different order, etc.). The preferred one (73%) was used to implement the functionality.

As to the affective dimension, measured through SAM and HQ scale tools (see section 3.4.5.) the evaluation revealed that the majority of viewers felt pleasure (70%), arousal (70%) and 'in charge' (63%) while using the prototypes. In relation to the HQ scale, where each pair of adjectives corresponds to opposing adjectives, and it is evaluated in a 7 points rating scale, the values obtained in 1, 2 and 3 rating scale were summed. The results achieved were the following: outstanding (67%), exclusive (80%), impressive (73%), unique (87%), innovative (87%), exciting (80%) and interesting (83%) which were very positive results and better than the ones achieved from the first generation prototypes, contrary to what was expected due to the raise in complexity.

4.3.3.2. Evaluating the High-Fidelity Prototypes

The high fidelity prototypes were evaluated through the following methods in the following order: **evaluation sessions** (see the viewer script of tasks in Annex I and the evaluator observation grid in Annex E), **questionnaires** (see Annex J), **interviews** (see Annex K) and **focus groups.** The evaluation had the participation of 15 persons: 5 students with higher technological literacy; 5 students with lower technological literacy, and 5 persons with low technological literacy. As to the 10 students, they were the ones that participated in first generation hight fidelity prototypes for the first time. As to the 5 persons with low technological literacy, they participated in the first generation high fidelity prototypes (and were the ones with more difficulties). As to the group of experts, they just participated in the evaluation sessions.

The evaluation of the high fidelity prototypes was conducted as in the first generation prototypes. The evaluation results are presented in the next sections.

4.3.3.2.1. iTV Interface

The results are presented in accordance with the type and order of the questions within the questionnaire. The more used **information levels** were 1 (47%) and 2 (40%), respectively topics and summary (Figure 55). In the majority of the cases, after using level 2 (summary), viewers did not select the topic because they were satisfied with the explanation, and when they were really interested in the topic they used level 2 instead of 3 (structured).

Nevertheless, they recognized the importance of having several possibilities available in order to improve flexibility and personalization and in this evaluation scenario, they did not have the intrinsic motivation to know more.

Figure 55. Viewer Using the Create Functionality in Information Level 1

From the **design** alternatives presented for the information level, 67% preferred the one that only shows numbers (1; 2; 3) over the one that also included words (1-Topics; 2-Summary; 3-Structured). They considered that it was easy to assume that the 1 means less information and 3 means more. On information levels 2 and 3, 73% of viewers preferred the video playing (both on embedded and overlay design while accessing the information). Between **embedded and overlay** design, 80% preferred embedded (as on previous experiences) (Figure 56).

However, an interesting discovery was viewers coherence considering that on all the other interfaces where video appears in a smaller size, 87% said that they also prefer the video playing (e.g. when they find a video with the search functionality). The argument was that, while doing other things (like searching videos and sharing web contents), if something interesting comes up in the video, they would be aware of it. These results are not in accordance with viewers decision from first generation low fidelity prototypes, where they decided that having the video paused would be the best option. Thus, these results reinforce that low fidelity prototypes, in spite of being very useful in many situations, do not provide a rich enough environment for a realistic evaluation of the interaction with dynamic media like video.

a) b)

Figure 56. Viewer Using the Create Functionality in Level 2

a) Embedded design; b) Overlaid design.

The OK button only needs label on first screens (73%). On the other screens only the Button is sufficient. An expressive majority (93%) of the viewers needed to look at the remote sometimes through all the evaluation process. Almost all viewers used the directional keys plus the OK buttons, instead of using the shortcuts (chromatic and 1, 2 and 3 keys), even the most technological literate (87%). Viewers learned how to use the interface: with some effort (27%) and easily (73%).

Globally, the achieved results, in terms of interface design evaluation (Table 6), are very positive and consistent. The questionnaire was constructed with specific validation questions which were written in the negative form, and those were the ones with low percentages against the other questions with high percentages. This indicates that viewers were focused while filling the questionnaires, the results are consistent and the interface design succeeded.

Table 6. iTV Interface Design Evaluation Results

	Nothing	Little	Average	Much	Very Much
Is Intuitive	0%	13%	7%	47%	33%
Is easy to use	0%	7%	20%	47%	26%
Has a fluid navigation	0%	0%	20%	53%	27%
Is visually pleasant	0%	0%	13%	27%	60%
Uses easy to understand keys	0%	0%	13%	40%	47%
Adapts to viewer needs (providing more or less information) and thus being flexible	0%	0%	13%	20%	67%
Is intrusive and distracts from essential	33%	27%	13%	*20%*	*7%*
Works well with the use of a MENU based system navigation	0%	0%	7%	33%	60%
Works well with the use of color keys	7%	20%	26%	*27%*	*20%*
Color keys are useful	0%	7%	20%	33%	40%
Works well with the use of underlines to show which topics may be chosen	0%	0%	7%	20%	73%
Used too many remote keys	67%	13%	7%	13%	0%
Could be better	0%	7%	6%	*60%*	*27%*
Is well designed	0%	7%	20%	20%	53%
Is appropriate to create and follow extra web contents	0%	0%	17%	*20%*	*63%*

One of our main concerns was to provide an adequate support to viewers' informal learning needs without disturbing their TV viewing experience. The results achieved were considered good, taking into account that only 27% (20%+7%) found the iTV interface distracting, namely, 3 (out of 5) viewers with less technological literacy, and 1 (out of 5) from the group with medium technological literacy.

As previously mentioned, almost all participants used the directional keys plus the OK button instead of using the available shortcuts (chromatic keys for functionalities and 1, 2 and 3 keys for choosing the information level). In terms of navigation, every task may be achieved through directional keys plus the OK button. In all remotes these 4 keys are nearby and are very easy to intuitively map key position with the expected movement. As to the 1, 2 and 3 keys, in spite of being easy to map to the info levels, on the remote used, they were distant from the directional keys. As to the chromatic keys, in spite of being more close to the directional keys, they are not so intuitive to map. Thus, considering that the use of the shortcut keys implied the need to look at the remote, participants did not tend to use them. It was interesting to see that in spite not using them, 47% of viewers considered that they work well and 73% recognized color keys usefulness. Thus, considering these results and that they provide useful shortcuts, it is our belief that, after some experience, viewers will tend to use them. These results were already expected. Direct access to functionalities (by using shortcut keys on the remote control) always allow viewers to reach the content faster, but they have problems with finding the right key and with the need to look frequently from TV screen to the labels on the remote control. In the majority of cases, it is just a question of time until the intuitive mapping of shortcuts.

The results presented so far answer our RQ3 (*What are the preferred interface designs for the relevant cognitive modes and needs in each scenario? Along the several options and functionalities, which interfaces work best to support the different cognitive modes (experiential and reflective) and levels of attention?)*. As to the results presented in Table 6, they positively answer the RQ1-a) and b) in what concerns the iTV (RQ1: *Which model interface design and functionalities are adequate in order to: a) Provide an adequate support to create and follow extra web contents? b) Have interfaces easy to use and understand in each of all devices (usability)?).* In fact, the well-conceived iTV interface (considering the high scores achieved in levels 4 and 5 of the Likert scale: “Much” and “Very Much”) is appropriated to provide an adequate support to create and follow extra web contents (83%) and is easy to understand (80%) and to use (73%).

Nevertheless, a high percentage of viewers (87%) stated that it could be better. When directly asked about what could be better in terms of iTV interface design: 20% did not answer, 27% told that no changes were needed, 33% suggested the use of other techniques in order to have an easier interaction (their main concern was the need to look at the remote) and the other 20% made suggestions related to aesthetics, legibility, coherence, and access speed aspects: move the name of the functionality being used from the bottom bar to the top of the screen, and keep the color used; when in information levels 2 or 3 and the overlay option is selected, then the embedded should have a square around it (and vice-versa) in order to be prepared to a change via a simple click; etc.

As to the **participants' comments** about the eiTV interface design, some interesting comments were: "After all, this is not difficult to use" (from a person with low technological literacy); "X <one of the most popular Portuguese cable TV operators> should have an interface like this" (from a student with high technological literacy when referring to our shortcuts); "when I'm navigating I don't need to look at the remote, only rarely I have to look" (from a student with average technological literacy); "It was very good to have 3 different information levels. I preferred levels 1 and 2 and only twice I decided to choose the topic after reading level 2 explanation" (from a student with average technological literacy); "the metadata information available was very appealing" (from a student with high technological literacy).

In general, and based on the presented results, we succeeded with the iTV interface design but some improvements should be considered.

4.3.3.2.2. Web Interface

In what relates to the Web Interface, it was possible to perceive from the evaluation that 13% of the viewers adapted to the web interface with some effort and 87% (40%+47%) adapted easily, which answers positively our RQ1-a in what refers to the PC.

In general, viewers considered the interface design as presented in Table 7. From this table, it is possible to answer positively our RQ1-b in what refers to PC considering that the web interface was considered easy to understand (93%) and easy to use (87%) (the values presented are the sum of the results obtained for "Much" and "Very Much"). It is also possible to answer positively RQ1-c (*Which model interface design and functionalities are adequate in order to: Create personalized web contents appropriate to give sequence and continuity to informal learning opportunities created by the visualization of the video (are they able to contextualize viewers in relation to what they first saw and provide further coherent content)?)* considering that to 87% of the viewers, the web interface immediately reminds the interface used on iTV.

Table 7. Web Interface Design Evaluation Results

	Nothing	Little	Average	Much	Very Much
Is Intuitive	0%	0%	7%	*20%*	*73%*
Is easy to use	0%	6%	7%	*40%*	*47%*
Has a fluid navigation	0%	0%	13%	47%	40%
Is visually pleasant	0%	0%	13%	27%	60%
Uses easy to understand keys	0%	0%	7%	20%	73%
It has an unclear organization	*67%*	*26%*	7%	*0%*	*0%*
Provides a good experience of use	0%	0%	7%	26%	67%
Immediately reminds the interface used on iTV	0%	0%	13%	27%	60%
Works well with the use of a MENU navigation similar to the one used on iTV	0%	0%	7%	33%	60%
Allows to quickly remember the navigation scheme	0%	0%	7%	47%	46%
Allows to quickly understand the application way of use	0%	7%	13%	33%	47%
Could be better	7%	6%	20%	47%	20%
Is well designed	0%	0%	20%	33%	47%

As to the web content organization, 93% (67%+26%) of viewers stated that it was not unclear, which was a very good result. The question was presented as a negative affirmation in order to test viewers' attention and the results are in italic in order to emphasize opposite valence.

Globally, the achieved results in terms of interface design are very positive and consistent. When comparing iTV results (see Table 6) with the web content results (see Table 7) it is possible to see that, in general, the results achieved for the web interface were better. In fact, the sum of values achieved for "Much" and "Very much" (the higher classification values, respectively corresponding to 4 and 5 in a Likert scale) were higher. A closer observation shows that the values achieved in the "Very much" classification were, in general, higher than the ones achieved in the "Much" classification (contrary to what happened with the iTV interface). The difference of results is understandable considering that viewers were using TV and PC to do the same tasks and these devices are very different and typically used in different cognitive modes. Nevertheless, the results achieved were very good. These results support RQ3.

In relation to **functionalities**: 60% considered that, when compared to the iTV interface, the Create functionality through the PC was easier to use, and 53% considered that it was more intuitive. These values were a good surprise considering that we were expecting that most viewers found the iTV interface more difficult than the PC interface, especially when referring to a functionality which requires more interactivity. In fact, a remote is more intrusive and difficult to use than a mouse, if considering a high level of interaction, and viewers are in the presence of devices traditionally used in different cognitive modes. Thus, the results seem to indicate that we have achieved a considerably balanced iTV interface. These results support RQ1-a), b) and RQ3.

It is important to mention that the intention of transmitting a sense of **unity** was achieved: 80% of viewers referred that when they entered the portal they immediately felt that they were inside of the same application, in spite of using a different device (positive answer to RQ1-c). As to the **contextualization** designed proposal, the majority of the viewers (73%) preferred the video playing. Nevertheless almost all of them complained about the time that they had to wait (87%). This delay was due to a technical problem that was identified and easily solved. 93% of the viewers considered that this type of visual contextualization (video or image) is absolutely needed with 87% preferring video and only 13% preferring image. When asked about other possibilities in terms of contextualization, 33% suggested the use of video and images simultaneously (answers to RQ3 in what refers to web content through the PC and answers RQ4: *What other functionalities would viewers like to have in this kind of crossmedia environment, capable to generate extra web content to video?)*. It makes sense considering that, on previous evaluations, the majority of viewers decided that the best choice was to use an excerpt of the video at the moment of the click (but in order to make sense, that excerpt needs to start a few seconds before the exact moment of the click). Thus, for a few seconds, the video that appears may be sooner than the moment being watched at the click moment. This may, in fact, turn to be a good option if also considering that, usually, few seconds separate the moment that viewers decide to click until they really do it. On these particular cases, when the video appears a few seconds before the moment of the click, to use an image of the exact moment of the click may turn to be helpful in the contextualization process.

As to the **participants comments** about the web interface, some interesting contributions were: “This works like a normal website but gives us much more” (from a student with high technological literacy); “The website has a lot of stuff but only the create functionality confused me a bit” (from a person with low technological literacy which said to be confused when asked to change between levels of information); “This is definitely a very dynamic website which is good, it captures our attention” (from a student with average technological literacy); “the use of a video from the moment of the topic choice helped me to remember where I was” (from a student with average technological literacy); “the web content interface is similar in the iTV and PC which is cool, because it’s easy to understand that it’s the same system, but we can use it everywhere” (from a student with high technological literacy).

4.3.3.2.3. Mobile Interface

Mobile interfaces were presented in low fidelity. A real Smartphone was used and the GUI was designed on power point and printed in a color laser printer, with the real screen size. All functionalities were designed in breadth and depth, and the designed interaction was very close to the final product. No mobile devices specific functionalities were explored and tested at this time, only the possibility to accomplish, via mobile device, the same tasks that were possible via TV and PC. The interaction with the GUI low (mixed)-fidelity prototype occurred via the Wizard of Oz technique to provide us with feedback at an early stage of development of the mobile prototypes without too much initial investment. However, although previous research on mobile devices stated the usefulness of low fidelity prototypes (Sá, 2009) the questions presented to viewers were not too specific and the results should be seen as indicative. This was due to the fact that we were in the presence of two additional variables that make the situation more complex: this is a crossmedia application and video is being used as the trigger to create web contents and not so easy to “watch” in low fidelity prototypes.

As a **whole**, the crossmedia application with the mobile devices was considered: more useful, easier to use (answers positively RQ1-b in what refers to mobile), easier to learn (answers positively RQ1-b in what refers to mobile), and more users would like to have it and would recommend it to a friend, when compared to having only iTV and PCs, with high percentages (87% and 93%), which answers positively RQ2 (*Is there a real advantage in connecting these* *devices in order to generate additional web content information to a video?)* and RQ5 (*Are the different devices (with different characteristics and thus different possibilities) as part of an ecosystem (in order to have an identical model and functionalities available across devices) easily adopted by viewers?)*. In general, there was no substantial difference of opinion amongst the 3 evaluation groups. Nevertheless, it was possible to observe that the group with poor technological literacy, in general, took more time to accomplish the proposed tasks and asked more questions. However, like the other two groups, they all made it and the enthusiasm was the same. Interesting to note, no considerable differences were detected between the group with high technological literacy and the group with average technological literacy. This may be explained by the fact that these groups included students that already participated on previous evaluations of the eiTV, so they were probably becoming more familiar with it. Thus, and in order to overcome this situation, these groups along with completely new ones were used in the following evaluations.

4.3.3.2.4. eiTV Functionalities

As to the functionalities, the more important dimensions about the evaluation are presented in Table 8 and support RQ3.

In general terms, and independently of the device being used, all available functionalities were evaluated and received good and coherent classifications, analyzed as follows:

The **Home** functionality, as expected, comprises the least interesting features but however was considered very useful. This means that, in spite of not having interesting features, which makes sense considering that nothing really new was presented, it was perceived as important. It was classified as the easiest to use which is also in accordance with the fact of not presenting anything new to viewers;

The **Web content** functionality comprises the more interesting features, was considered very useful, the third more interesting, and no particular effort was needed in order to use it;

Table 8. Functionalities evaluation

Note: in relation to the first 3 questions presented in the table the information was gathered from different tables, that is why the sum of each question values is higher than 100%. As to the other questions, they were presented to viewers as individual questions and they could only choose one option.

Viewers considered	Home	Web content	Create	Search	Share	Profile
Available features interesting	53%	87%	80%	73%	73%	60%
Made some effort to use the Functionality	7%	20%	20%	33%	27%	53%
Functionality Useful	87%	80%	87%	87%	80%	53%
Most interesting Functionality	0%	13%	53%	20%	14%	0%
Least interesting Functionality	27%	7%	0%	7%	13%	46%
Most useful Functionality	13%	20%	47%	13%	7%	0%
Least useful Functionality	20%	7%	0%	20%	7%	46%
Easiest Functionality	73%	7%	0%	0%	7%	13%
Most difficult Functionality	0%	7%	47%	13%	13%	20%

The **Create** functionality comprises interesting features (second best classification), was considered the most useful, the most interesting but also the most difficult to use. Nevertheless, in spite of that, the effort in order to use it was not high compared to other functionalities. This may indicate that since it was recognized by viewers as the most useful and interesting (affective dimension) functionality, the effort was considered relative in terms of cost-benefit. To some extent, these results show how the affective and cognitive dimension may affect the adoption. In fact the create functionality, which was considered as the most difficult but the most useful, was used with success and pleasure meaning that in this particular case the functionality difficulty did not affect the cognitive dimension which did not affect the adoption of the application. These results also support that in spite a lower usability, when a functionality or application is perceived as useful and interesting it will probably be easily adopted;

The **Search** functionality comprises interesting features (third best classification), more effort is needed in order to use it (when compared to the previous presented), was considered very useful, the second most interesting functionality and not very difficult to use;

The **Share** functionality comprises interesting features (also third best classification), small effort is needed to use it, was considered useful, the third more interesting functionality and the third more difficult;

The **Profile** functionality does not comprise very interesting features, was the functionality that required the highest effort from viewers, was considered the least interesting and the least useful and the third more difficult functionality. These results were already expected and corroborate to the idea that viewers do not like to fill in forms. On the other hand, in spite of absolutely needed, the importance of this functionality is not visible to viewers. Probably, it was the fact of being perceived as the least interesting and least useful that lead to its classification as the one which requires the biggest effort in spite of being perceived as not difficult. These results support that in spite good usability, when a functionality or application is not perceived as useful it will probably be avoided.

4.3.3.2.5. eiTV Application in General

As to the eiTV application, as a **whole**, 87% of the viewers considered it useful (detailed results on usefulness in Table 9). 73% also considered it easy to use (details in Table 10), 60% easy to learn (details in Table 11) and 87% of viewers are satisfied with it (details in Table 12).

Table 9. Final eiTV application: usefulness

	Nothing	Little	Average	Much	Very Much
It helps me be more effective	0%	0%	20%	17%	63%
It helps me be more productive when I watch video	0%	0%	13%	*40%*	*47%*
It is useful	0%	0%	13%	*17%*	*70%*
It gives me more control over the information that I watch on video	0%	0%	7%	33%	60%
It makes the things I want to accomplish easier to get done	0%	0%	27%	33%	40%
It saves me time when I use it	0%	0%	27%	47%	26%
It meets my needs	0%	0%	23%	47%	30%
It does everything I would expect it to do	0%	13%	30%	37%	20%
It comprises very useful functionalities	0%	0%	10%	37%	53%
I like to be able to access my eiTV application and its functionalities from any device	0%	0%	3%	*27%*	*70%*
I like the flexibility that the application gives me: now I can use it through the TV at home, later I continue through the smartphone on my way to school, etc	0%	0%	0%	*3%*	*97%*

These results, which dimensions are essentially intended to measure **usefulness**, were considered very good. As may be seen from the table and when summing the higher values from the Likert scale (“Much” and “Very

Much") none of the questions is below 50%. As some of the more relevant: 87% claim being more productive when watching videos and 97% like the idea of accessing eiTV from any device. These results answer positively RQ1b, RQ2 and RQ5.

Table 10. Final eiTV application: ease of use

	Nothing	**Little**	**Average**	**Much**	**Very Much**
It is easy to use	0%	0%	27%	*40%*	*33%*
It requires the minimum of steps to do what we want to do	0%	0%	33%	34%	33%
It is flexible	0%	0%	20%	33%	47%
It does not require effort to use	0%	0%	13%	*40%*	*47%*
May be used without the need to read instructions	0%	7%	13%	53%	27%
No inconsistencies were found while using it	7%	7%	26%	40%	20%
Both occasional and regular users will like the application	0%	0%	13%	*34%*	*53%*
It is easy and fast to recover from errors	0%	0%	7%	53%	40%
May always be used with success	7%	13%	27%	40%	13%

These results, which dimensions are essentially intended to measure **usability**, were considered very good. Some of the most relevant were: 73% of viewers found the application easy to use, 87% stated that it does not require effort to use it, and 87% said that both occasional and regular viewers would like the application. These results answer positively RQ1-b.

In what relates to how easy it was for viewers to learn how to use the application, the achieved results are presented in Table 11.

Table 11. Final eiTV application**:** ease of learning

	Nothing	**Little**	**Average**	**Much**	**Very Much**
I learned to use it quickly	0%	7%	20%	40%	33%
I easily remember how to use it	0%	6%	7%	*40%*	*47%*
It is easy to learn to use it	0%	0%	40%	*27%*	*33%*
I quickly become skillful with it	0%	7%	20%	47%	26%
The interfaces are intuitive	0%	0%	20%	33%	47%

As to the obtained results they were good and support RQ1-b and RQ5. However it is interesting to note that 60% of viewers found the application easy to learn, while 87% consider that is easy to remember how to use it. Thus being, this may indicate that, from a cognitive perspective, the application was well designed. In fact, in spite of some difficulties at the beginning, which may be considered natural due to the amount of devices, functionalities and contexts of use involved, it is very easy to remember how to use the application. These results answer positively RQ1-b and RQ5.

In what relates to viewers satisfaction, the achieved results are presented in Table 12.

Table 12. Final eiTV application: satisfaction

	Nothing	Little	Average	Much	Very Much
I am satisfied with it	0%	0%	13%	*34%*	*53%*
I would recommend it to a friend	0%	0%	20%	*33%*	*47%*
It is fun to use	0%	0%	26%	*27%*	*47%*
It works the way I want it to	0%	13%	20%	40%	27%
It is awesome	0%	0%	20%	27%	53%
Would like to have it	0%	0%	13%	*34%*	*53%*
It is good to use	0%	7%	13%	33%	47%

The results related with satisfaction, which main goal is to evaluate the **affective dimension** were very good. In fact, independently of the devices and functionalities, when evaluating the whole application: 87% of viewers were satisfied with the final result, 80% would recommend it to a friend, 73% found it fun to use and 87% would like to have it. These results answer positively RQ1-a, RQ1-b, RQ2 and RQ5.

The results from table 13 which main goal is to evaluate **cognitive overload** (Question D.5.1. from the questionnaire presented in Annex J) were considered very good. Considering that these questions are in the negative form, the Likert scale values analyzed were 1 (nothing) and 2 (little). The higher these values the better the results.

Some **usability** problems were detected, as for instance: the lack of shortcuts to facilitate and speed the navigation process through longer lists of chosen topics (one option could be to implement circular navigation); the navigation along lists of options is slow (this was due to the need that we had to adjust the remote sensibility in order to prevent errors in the topics selection.

Table 13. Global eiTV application: cognitive overload

	Results from answers: Nothing + little
How mentally demanding were the tasks?	73%
How physically demanding were the tasks?	73%
The temporal effort I had to do in order to not take too much time	67%
How hard did I have to work to accomplish my level of performance?	73%
How insecure, discouraged, irritated, stressed and annoyed was I?	80%

In fact, at first the remote was slow and the viewers clicked several times in order to choose a topic because it was not immediately clear that the application understood the viewer action); the navigation bar to change between pages of topics, in spite of contributing to a faster search, confuses viewers when they need to change to the other option boxes on the right side of the screen, etc.

As to the **participants comments** about the eiTV application in general, some interesting comments were: “This is awesome! Hey teacher, when can we have this at home?” (from a student with high technological literacy); “This was in fact a good idea, I would definitely use it for different types of programs” (from a student with average technological literacy); “well, I’m not a technology fan, but this is not as difficult as I was thinking, at least when creating from iTV” (from a person with low technological literacy); “Using different devices in order to do the same tasks was not strange for me, I’m used to the internet on PC and mobile, so…” (from a student with high technological literacy); “In spite of using different devices, it was not difficult to understand that the system was the same due to the interfaces” (from a student with average technological literacy); “the idea of using the system while moving around through the mobile is very appealing, there’s a lot of stuff that we can do while waiting for an appointment or transportation” from a student with high technological literacy.

As to **Users that had Already Participated**: In relation to the 10 viewers (students) that already participated in the evaluation of the previous prototypes: 80% considered this version more intuitive, more flexible (90%), with more useful functionalities (100%), they liked the Search functionality (90%) and they liked the use of an aggregator portal (90%). These results were very encouraging, since they prove that our effort was worthwhile and our design approach succeeded.

The questionnaires results, presented in previous sections, corroborate in general what was observed and the interviews results. From the observation, we noticed that viewers had some difficulties at the beginning of usage. However, after some minutes, they seemed very comfortable using the application, even the least technologically literate – somehow unexpected.

As to the Research Question 4 (already identified in the text but with more results to present) and Research Question 6, not yet identified within the text:

***RQ4**: What other functionalities would viewers like to have in this kind of crossmedia environment, capable to generate extra web content to video?*

As to this research question, within the text only one viewer specifically suggested that the application could work integrated with the Facebook. When asked about other possibilities in terms of web content contextualization, 33% of viewers suggested the use of video and images simultaneously (more than a specific functionality, this was an alternative option to an existent functionality). However, from the interviews and focus groups, some ideas came up and the ones with better results were:

- Use the mobile phone to: capture videos, images and sounds to personalize the web content 80% (12 out of 15 viewers); search something based on GPS coordinates 73 % (11 out of 15);

- Synchronize devices in order to used them simultaneously 80% (12 out of 15);

- Have detailed editing features in order to personalize the web content after generating it 60% (9 out of 15 viewers);

- Use some facebook functionalities, as for instance share a web content but keeping some information as private 53% (8 out of 15 viewers);

- Have a live chat integrated within the eiTV 40% (6 out of 15).

The number of viewers mentioned in each option is not the number of viewers that launched the idea individually, but the number of viewers that were enthusiastic with the idea.

RQ6*: Were the proposed frameworks, for crossmedia and iTV, adequate and efficient?*

Considering that the design and use of the eiTV application and the iTV interface were conducted following the directions identified on both crossmedia and iTV conceptual frameworks, and that the achieved results were much better than the ones achieved with the first generation prototypes, we have reasons to believe that we were capable to identify critical points and possible solutions to the design of crossmedia and iTV applications in this context.

4.3.4. Discussion

Section 4.3. described, the eiTV second generation phases. Low and high fidelity prototypes with interaction proposals where designed, developed and evaluated. From those tests, it was possible to conclude that, in general, and amongst other things, the application was considered: usable, intuitive, useful, well designed, very interesting and important to have. Considering the results, presented in section 4.3.3.2., it was possible to perceive what works best in terms of design choices and functionalities and that the initial goals where achieved.

In relation to mobile devices, the main functionalities were tested with low fidelity prototypes. Mobile devices in this context were used to test the idea of mobility, to show viewers the planned interfaces and to gather some suggestions, in order to prepare for the third generation. In fact, and in general, the results showed that the integration of the mobile devices in the eiTV environment was appreciated and would likely be successful. The use of a low fidelity prototype (in what refers to this specific device) was a good option in a preliminary phase, considering that it helped detecting most significant usability problems, testing ideas, and it provided us with good clues for future developments, with a reasonably low investment. Next generation prototypes will include all the functionalities working in all the devices and improved options in terms of design, in order to accommodate viewers suggestions and our own insights.

4.4. eiTV Third Generation: Going Mobile

In conceptual terms, the keyword here is ***MOBILE*** and the flexibility inherent to have mobility and the coexistence of different devices and contexts of use. The idea is to take the best advantage from mobile devices (mobility) for flexibility in the access to info from different devices, and their synchronization with other devices (the devices were used in a complementary way), to simultaneously access different but related information on different devices. The latter is usually referred to as the 'second screen' phenomenon. As an example, watch the video on the computer while using the mobile device to watch the generated web contents about that video. This section presents the design, prototyping and evaluation of this eiTV third generation

4.4.1. Analysis and Design

This section presents the third generation eiTV application conceptual model and the architecture.

4.4.1.1. Conceptual Model

In the second generation, the eiTV was redesigned and extended with an improved and more usable interface due to the flexible and simplified navigational model, and increased functionalities (Prata & Chambel, 2011a). In the third generation, the application still works as a portal (Prata & Chambel, 2011b), with small improvements in terms of interfaces based on the second generation evaluation feedback, and it was extended with the Device Functionalities (DF) meaning that the complete list of functionalities or options is: **Home**, **Webcontent**, **Create**, **Search**, **Share, Profile** and **DF.** The main goal of this new functionality is to aggregate a list of new options that varies depending on the device being used and to take the best of the most promising device in terms of interaction possibilities and mobility (the mobile phone). Nevertheless, it was also implemented on the other devices with more limited possibilities due to these devices characteristics when compared with mobiles, in this respect.

One of the main advantages of mobile devices in our scenarios is to allow the capturing of contextualized information (contextualized capture). The type of capture depends on the devices technology, as for instance: GPS, movement sensors, smell sensors, taste sensors, etc. and the current tendency is the increasing of sensors on mobile phones. This fact opens doors to a new range of richer functionalities, as for e.g. content-based search, which will allow to expand the architecture of the application to a higher level. Let's imagine some scenarios based on the mentioned technologies and functionalities:

- With the GPS technology, viewers may be able to capture contextualized videos and images (videos and images from a specific spot), which may be used in order to search other videos and images related to that particular place (location-based search) or search other videos and images related to the content of the captured ones (content-based search);
- With movement sensors viewers are, for e.g., able to capture some of its own, or someone else's, dance steps and, based on that, search for videos where that type of dance steps are being used;
- Through smell sensors, viewers may capture a specific smell and use it in order to search videos with that same smell on it, the same happening for taste.

In order to technically implement these scenarios of use, two things are needed: sensors and to have the information cataloged in accordance. In our opinion, due to the raising importance of the human senses dimension in informatics, this will occur soon. In fact, in what refers to smell and taste sensors, for example Cheok (2013) is conducting an important research.

On the second generation, a first essay with low fidelity prototypes on mobile phones was conducted. No extra functionalities were available beyond the ones available through TV and PC. The goal was just to start imagining and testing the same functionalities and interfaces from all devices and have some viewers feedback on this. However, in this third generation, the role of mobile devices evolved and goes further. Instead of just supporting the same tasks as TV and PC, they are supposed to contribute with their specific tools, e.g. GPS, allowing real mobility and taking the best of each device involved. In sum, the main idea behind this generation is to take the best advantage from mobile devices (mobility) and from their synchronization with other devices (complementarity).

Consistency in User Experience (**UX**) and the perception of the application 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** viewers, give them a sense of unity, **continuity** and **consistency** in their UX and to allow a smooth transition among media and devices to achieve a good **UI Migration**.

4.4.1.2. Application Architecture

As in the previous generations, a Client-Server architecture was adopted for the eiTV application (see Figure 57) which in essence works as described in generation 2 (section 4.3.1.2.). The only difference now, in terms of architecture, is the possibility to synchronize the devices within the application and, in conceptual terms, take the best advantage of specific devices characteristics, with a special focus on mobile devices (for e.g. mobile phone).

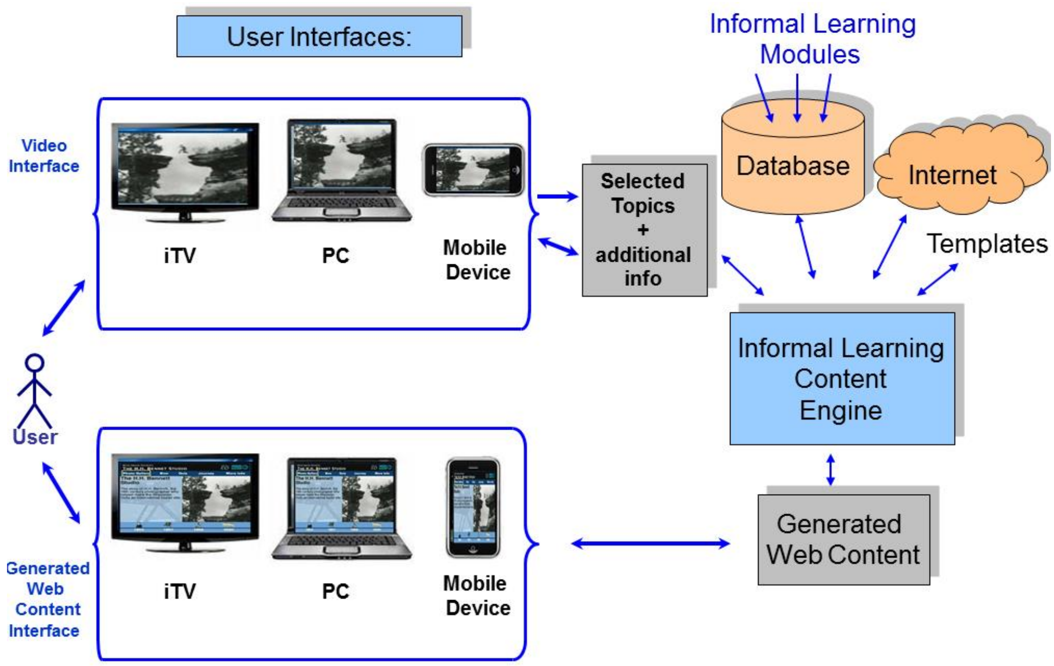


Figure 57. eiTV Third Generation Architecture

As mentioned, the main advantage of mobile devices is to allow the capturing of contextualized information and for that they need sensors which have an impact in terms of the architecture.

4.4.2. Prototyping

The architecture and the main features available in iTV and PC contexts were already explored and described in previous sections of this thesis and in previous publications (Prata *et al*., 2010c; Prata & Chambel, 2011a, 2012), as well as the languages and software tools used. Now the focus in on the introduction of mobile devices, and their specific functionalities and design, in a synchronized way, in this crossmedia video-based application. In these prototypes there is a **mixed type of trigger activation** considering that changes in the UI are partially triggered by the user and partially automatic (when the eiTV detects another device which may be used to synchronize with the one being used, in a second screen fashion). As to the **timing** dimension, the migration occurs **immediately** after being triggered by the user.

4.4.2.1. Extended eiTV Functionality

The ‘Device Funcionalities’ (DF) is the new functionality set added to the application. The group of six functionalities from the second generation was now expanded to seven: Home, Webcontent, Create, Search, Share, Profile and **DF**. These functionalities are available: at the ‘departure point’, which occurs while watching the video and generating the web content, and at the ‘arrival point’, when accessing, editing, etc. the generated web content. Six out of these seven functionalities allow the same actions on iTV, PCs and Mobile phones, while the DF available options vary depending on the device, as may be seen from Table 14. The DF functionality comprises the following options: Device Interface, Add GPS coordinates (only when accessed from mobile phone), Devices synchronization, Video, Photos and Other files. These options, which main interface may be seen in Figure 58-a are described next:

- **Device Interface** - this option, available from all devices, allows to minimize the eiTV application to a small icon without exiting. This means that the viewers will have the usual device interface with the icon just to remember them that the application is open. The icon to use was chosen during the low fidelity evaluation and viewers agreed that this approach is the more intuitive. This option allows **flexibility**, **control** and is prepared for viewers changes in **cognition modes**;

- **Add GPS coordinates** - only available from the mobile device, this option allows viewers to simply add GPS coordinates to web contents, or add some text annotation as extra input. This means that viewers are able to simply add GPS coordinates to their web contents without the need to have those coordinates associated to a video or a photo. This option allows **flexibility, interoperability, adaptability, continuity,** supports **heterogeneity** and provides viewers with a ubiquitous application;
- **Devices synchronization** – this option allows synchronizing devices, in a second screen manner, in order to use them in a complementary way. An example is to use the TV to watch the video and the PC to access related web contents generated. This option provides **flexibility**, **control, synergic use, interoperability, adaptability, continuity, transparency,** is prepared for viewers changes in **cognition modes** and **needs,** supports **heterogeneity** and in terms of **redundancy** allows the use of devices in a complementary way;
- **Video** - this option allows to generate a video, or search one from the gallery. For that video, other options are also available (search related videos or photos by GPS coordinates when through mobile devices; add metadata to that video through written keywords and in order to classify the video; search related videos or photos by metadata and export the video to eiTV web content). These options allow **flexibility**, **control, personalization, contextualization, continuity**, are prepared for viewers changes in **cognition modes** (considering that the mentioned options were designed in order to support a more and less cognitive modes. As an example, when viewers decide to add a video to a web content they may simply export it to a generic place called ‘MyInput’ or to a very specific place within that web content) and take advantage on the **previous experience,** thus accommodating frequent viewers, and providing us with an ubiquitous application;
- **Photos** - this option allows to take a photo or search one from the gallery. In conceptual terms it works as the Video but having a photo as the departure point;

- **Other files -** this option allows to make an audio file or search one from the gallery and export it to the eiTV. Also available to export SMS or MMS contents, when through the mobile phone. This option provides **flexibility** and **personalization**.

All these functionality options were designed in order to take the best advantage of each device characteristics. However, these options vary depending on the device being used as presented next on Table 14.

Table 14. 'Device Functionalities' variations

Available Options	**TV**	**PC**	**Mobile Phone**
Device interface	✓	✓	✓
Add GPS coordinates	X	X	✓
Devices synchronization (ecosystem of devices)	✓	✓	✓
Video (use one from gallery or make one):	✓ (only use videos from the box)	✓ (make one if PC with web cam)	✓ (use and make)
- Search by metadata	✓	✓	✓
- Search by GPS	X	X	✓
Photos (use one from gallery or take one):	X	✓ (take one if PC with web cam)	✓ (use and take)
- Search by metadata	✓	✓	✓
- Search by GPS	X	X	✓
Other files (use one sound file or make one; add MMS and SMS)	X	✓ (only sound files)	✓

This options variation only occurs with the DF functionality. In what relates to the first six functionalities (Home, Webcontent, Create, Search, Share, Profile), in spite of sharing the same actions amongst devices, they were not provided exactly in the same way in terms of interface, considering that, as explained in the second generation, different devices have different characteristics in terms of technology, predominant cognitive modes, screen sizes, etc.

4.4.2.2. Mobile Devices Specific Features

In order to have each device doing what it is most suited for, contexts of use, device characteristics, and cognitive and affective aspects associated to their use were studied. After that study, and in what concerns to *mobile devices specific features*, the following were made available: location-based search and content-based search, explained and illustrated as follows:

- **Location-based search using GPS** - allows viewers to search videos and photos related to their current location. As an example, when near the Liberty Statue, the viewer may use this functionality to search, from eiTV and the internet, videos and pictures related to that specific spot. In order to illustrate this feature, Figure 58 presents the option of using the GPS coordinates, in this specific case, associated to a video or photo (being captured in the moment) to search other related videos or photos. To search from a photo or video occurs via similar interfaces. Nevertheless, the search may occur simply by GPS coordinates without the need to use or capture any specific video or photo.

Figure 58. 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.

In low fidelity prototypes two proposals were presented which comprised, amongst other things, two options for accessing the popup menu from Figure

58-c and which were: through a specific button designed in the interface or through the ‘menu’ own mobile phone typical button. The majority of viewers (70%) preferred the second option, thus it was implemented. As to the presentation of found related videos and images, Figure 58-d, additional info was needed in order to distinguish videos from images. From the two proposals, the one with the play icon embedded in the thumbnail was the preferred (77%).

As to the icons presented in the popup menu, they were also validated with very good results. In terms of **usability**, the option menu presented in Figure 58-a was considered very good.

Figure 59. Adding metadata to a video

Video capturing and metadata adding: 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 is choosing to record a new video; c) The viewer is choosing to add metadata; d) The keyword ‘son’ was added to the video. By pressing the ‘+’ button, viewers will be able to add more keywords.

- **Content-based search** - allows viewers to take a photo or shoot a video and search based on the photo or video content. This feature, in order to be more effective, should be automatic and rely in the adoption of a pattern recognition approach (Jesus, 2009), complemented with the possibility of viewers providing their own metadata manually, something that viewers are very used to do through keywords. Considering that, search algorithms were not in the scope of this thesis, and the application may be later integrated with other authors' works in this specific area, as for e.g. Jesus (2009), the focus was on the options of providing viewers with the possibility to search by metadata which is also necessary and the search by similarity would have a simpler interface using an image or video as search criteria. In order to illustrate this feature, Figure 59 presents the option of shooting a video and add metadata, in this case two words were added: son and chiuaua. Later, this video may be used for searching related content-based videos and images as presented in Figure 60[12] where the search was made by the keyword chiuaua.

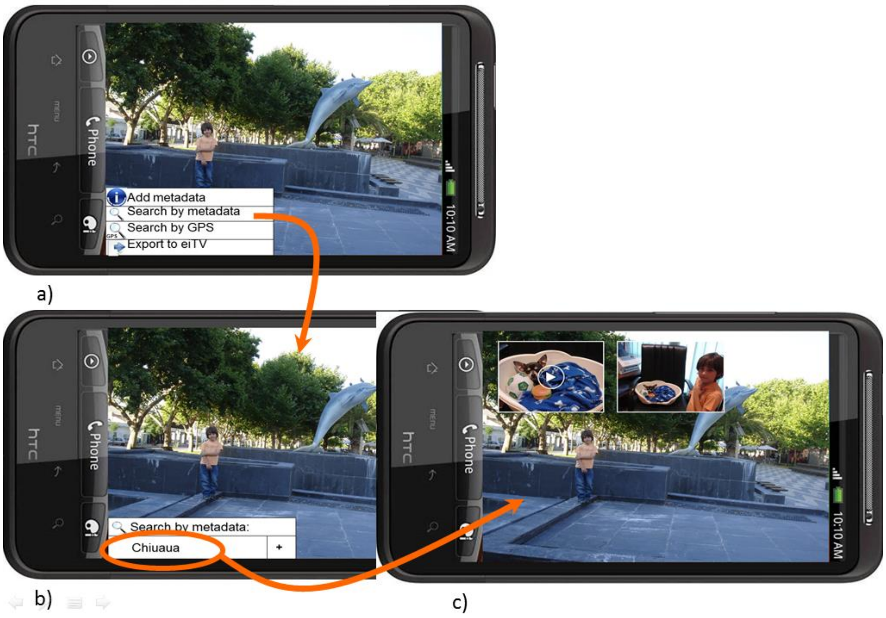


Figure 60. Searching videos and photos by metadata

a) The viewer is choosing to search by metadata; b) The keyword 'chiuaua' was added to video and images search; c) The two results – one video and one photo recorded with chiuaua as keyword - appear as thumbnails embedded in the video used for the search.

From the low fidelity prototypes usability evaluation, it was possible to perceive that, in general, all the interfaces related to the options: add metadata,

[12] In this figure it was assumed that the reader already understood how to reach this option from previous pictures, for e.g., figure 59 a) and b). Nevertheless, in this case, in what refers to figure 60 b) the chosen option was 'Gallery' instead of 'Record' considering that the video was previously recorded.

search by metadata, search by GPS and export to eiTV, were considered very good and quickly understood by all the viewers.

4.4.2.3. Design Options Underlying the Whole Crossmedia Application

Several improvements, in terms of functionalities and interfaces, were implemented in order to better support the important conceptual questions identified in chapters 1 and 3 and based on the feedback obtained in previous evaluation moments and from our own insights.

4.4.2.3.1. Navigational Model

As part of a larger Crossmedia application, the design challenges identified in section 3.2. were considered in the mobile devices design. As to the cognition modes, all functionalities (central or specific to mobile contexts) were designed to accommodate viewers' changes in cognition modes, attention levels, and different levels of technological literacy or preferences. The basic features, which were first implemented in first generation prototypes and later evolved in order to be adapted to the second generation prototypes and its portal structure and functionalities (Home, Webcontent, Create, Search, Share, Profile) were now made available on the third generation prototypes complemented with a new **DF** functionality, a new set of features and options and improved interfaces. These basic features provide viewers' with **personalization**, **flexibility**, **contextualization**, **continuity**, **coherence**, **usability**, **adaptability** and are adapted to different **levels of attention** and changes in **cognition modes, goals** and **needs**. Figure 61 shows an example of these basic features being used now on the third generation navigation model. A web content was created through a mobile phone, some topics were consulted and chosen in information level 2, and text and three files were added to the generated web content which was also watched through the mobile phone.

4.4.2.3.2. Exporting Files

Other options are also available as to export video and photos to the eiTV application (meaning that videos and photos will be transferred to the generic 'MyInput' tab or to a specific place within the web content, allowing to enrich the web content with more information). These options provide the application with

flexibility, **personalization**, **continuity** and **adaptability**. Figure 62 illustrates the option to export other files (in the case of the mobile phone device: audio files, SMS and MMS) to the eiTV application. This functionality is also available from PC (with similar interfaces) but, from there, only audio files may be exported, considering that SMS and MMS are not used in PCs. TV does not support this functionality (see Table 14).

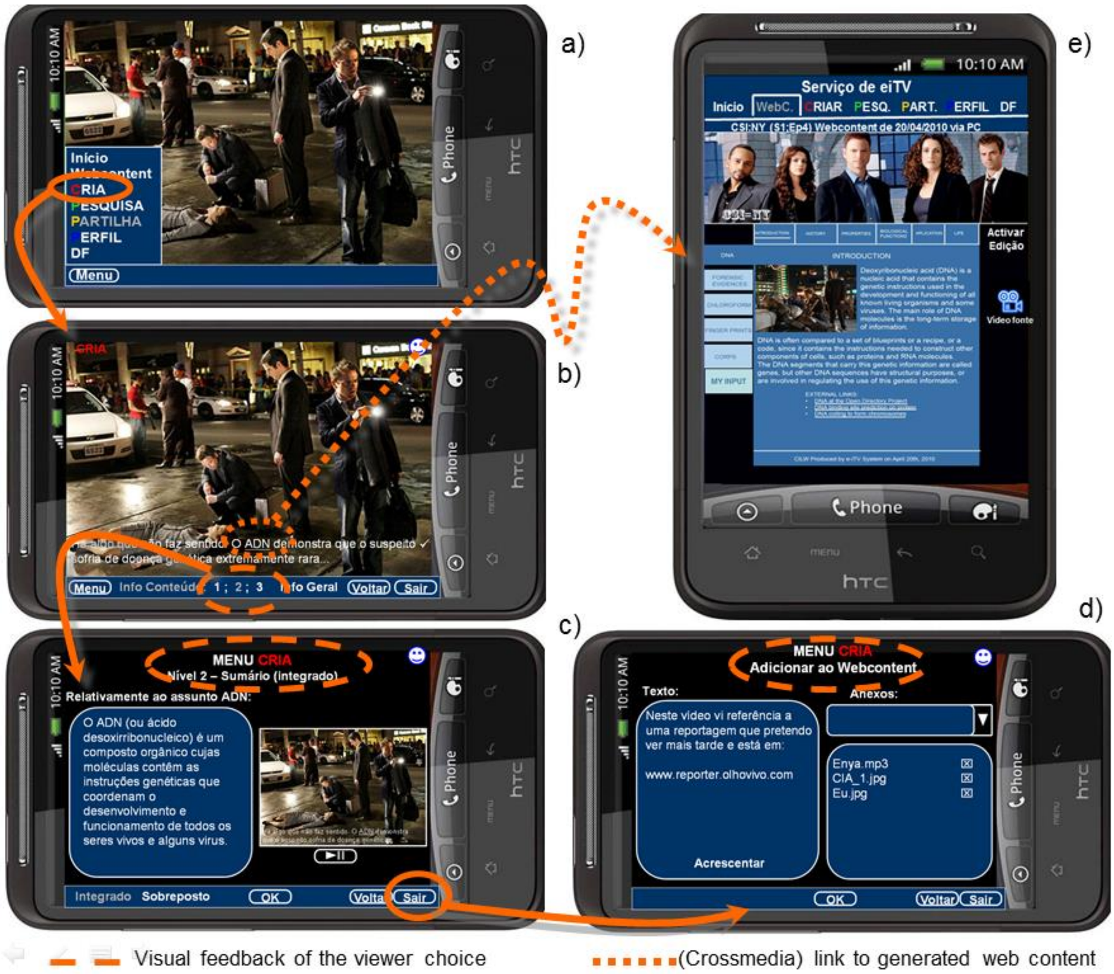


Figure 61. Create Functionality

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

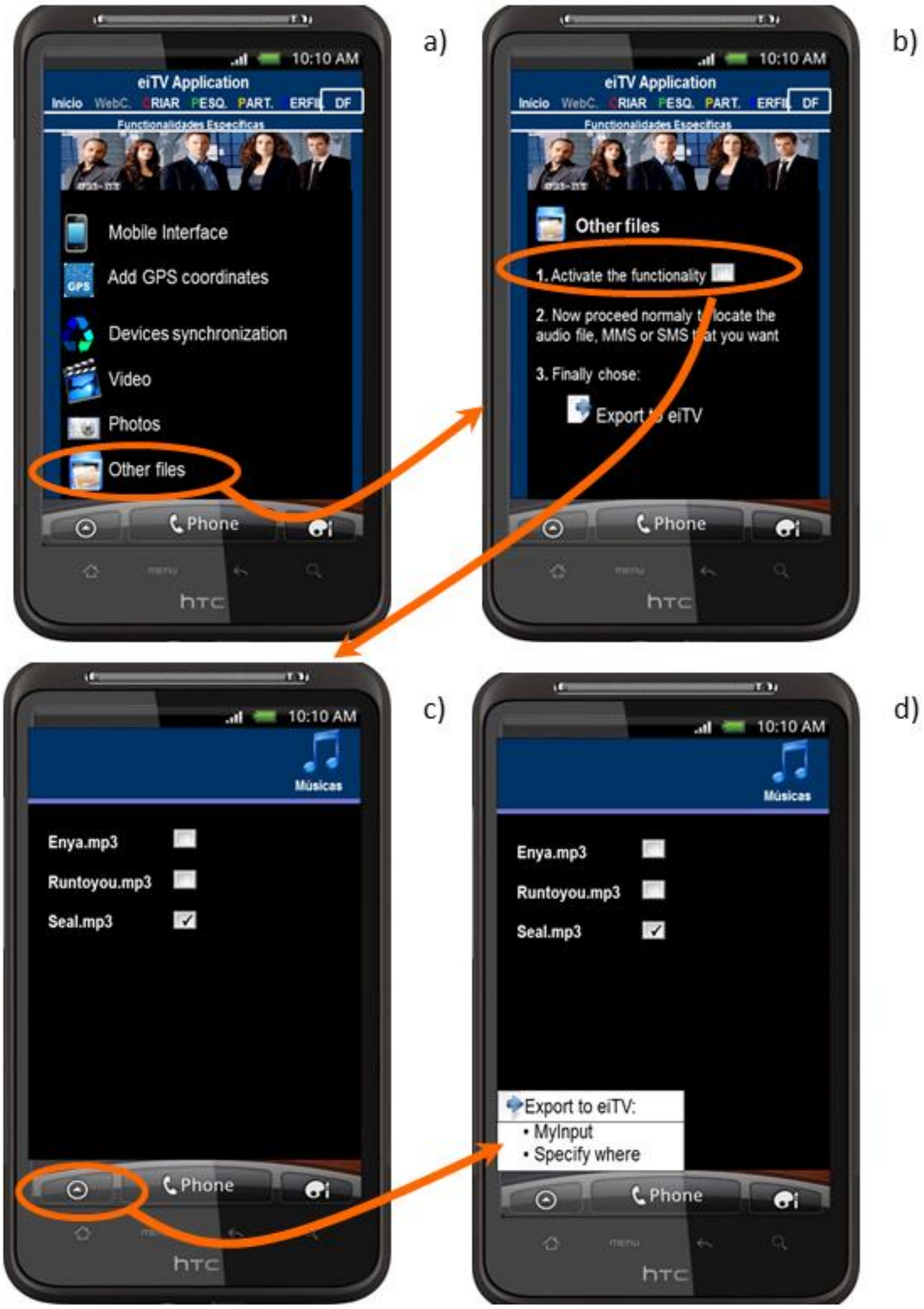


Figure 62. Export files to eiTV

eiTV Mobile Interface to add files other than video and photos to the eiTV: a) Options available at the DF functionality and 'Other files' option being selected; b) Possibility to choose what to add: sms, mms or audio files. The viewer is choosing to export audio files; c) Viewer chooses which audio files to export and uses the phone button to activate a specific menu; d) The viewer chooses to export the audio files to 'MyInput' tab or to a specific place within a specific web content.

From low fidelity prototypes it was possible to observe some hesitation around the use of this option. That was why a interface with detailed instructions was provided (Figure 62-b). This option provides the application with **flexibility**, **personalization**, **adaptability** and **error prevention**.

4.4.2.3.3. Devices Synchronization

The possibility to synchronize devices was designed and implemented in order to allow the application to work as a true ecosystem of devices. Figure 63 illustrates this option via mobile phone. When accessed through PC and TV, the same interfaces are available. Only the interface presented in Figure 633-a) changes considering that 'Add GPS coordinates' is a mobile phone specific option.

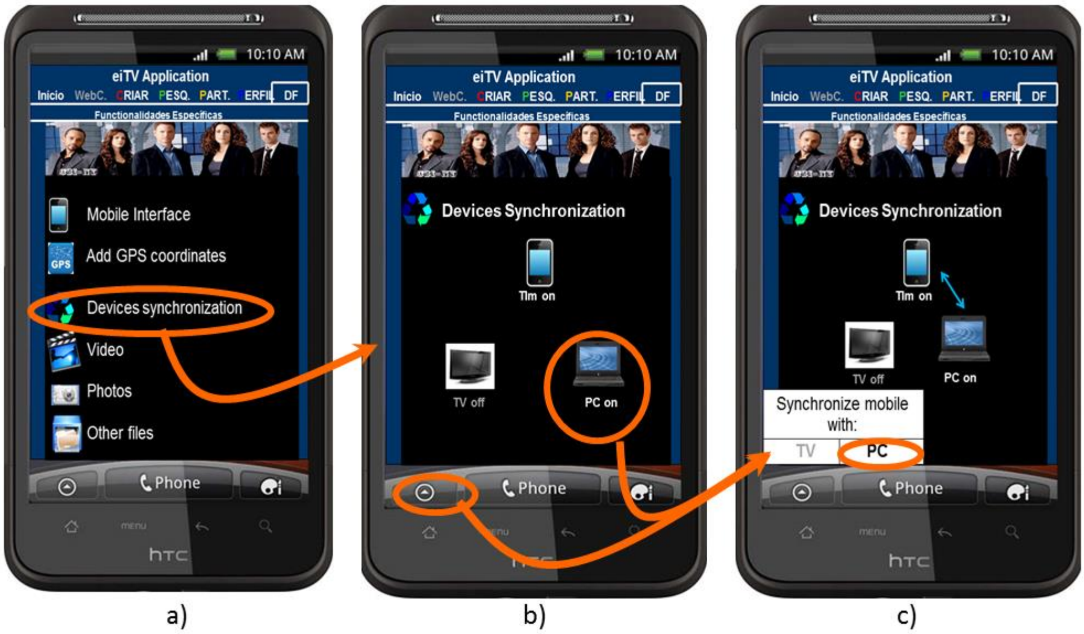


Figure 63. eiTV Devices Synchronization

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).

As may be seen in Figure 64 the viewer is watching a video on the TV with a previously generated web content. Thus, he decided to synchronize iTV with PC and mobile device in order to simultaneously access, through these devices, the generated web content about that video.

This option provides the application with **flexibility**, **personalization**, **continuity**, **adaptability**, **synergic use**, **transparency**, **interoperability, coherence, UX,** accommodates changes in **cognition modes** and in terms of **device redundancy** it shows how the devices may work in redundant or complementary ways.

Figure 64. Viewer Using Devices Synchronized

4.4.2.3.4. Extra Topics

While watching a video in order to generate a web content, it is now possible to select any topic from the conversation. On first generation prototypes three topics were available for each phrase or subtitle in the documentary genre, and one topic was made available for the CSI. On second generation, the CSI prototype was again implemented with one topic available for each phrase or subtitle. Now, on third generation, the viewer may select the ‘+Topics’ option to access the list of all topics for that specific moment (watch Figure 65). This list includes the default topics (the ones with higher probability of being chosen and that were previously defined by the program author or supplier), the new topics which are identified by having (+) in front of the topic name (and which also appear in the subtitles), and the extra topics related to other information on screen (but not in the subtitles), as for e.g. to help us select someone’s specific data (name, e-mail and affiliation) to send to the web content. These last topics are identified through the use of an icon resembling a person as in the messenger icon. This functionality provides viewers with more **flexibility** and **personalization** over their choices, it is adapted to changes in **cognition modes** and in terms of interface design it takes advantage on the viewer **previous experience**. In order to improve **contextualization** when these topics appear in the generated web content, they are in a different colour (has it happens when viewers import external files to a web content), meaning that those extra contents resulted from viewers' personalization.

Figure 65. eiTV Extra Topics selection

From the low fidelity evaluation, it was possible to perceive some adjustments in order to make this feature more usable, for e.g., two interfaces were tested, one presenting the complete list of topics (the chosen option) and another interface only including the extra topics. Viewers argued that the inclusion of all topics on the list is better considering that all the possibilities are presented at any moment which provides them with more flexibility.

In the first generation prototypes, and concerning the documentary genre, based on viewers and experts evaluation three selectable topics were defined as the maximum (while in the CSI one selectable topic was the maximum).

Thus, due to its dynamics, no space in terms of interface, was available in the documentary in order to accommodate different types (content or meta info) and levels of information (1, 2 and 3) and with different layouts (embedded and overlaid). This 'extra topics' feature opens doors to the study of design models adequate to support the documentary dynamics considering that all topics of interest may be used (in spite not immediately visible, but reachable through '+Topics').

4.4.2.3.5. Web Contents

The web content was implemented with new options that mainly improve viewers' **contextualization**, **personalization**, **flexibility**, **continuity** and provide better accommodation for changes in **cognition modes,** as follows:

- **Contextualizing Video -** through the web content, it is now possible to access the video that was used to generate it, by simply clicking an icon with a video camera, for familiarity, taking advantage on previous viewer experience. Similarly, through a video it is possible to access the generated web contents if there is any (see Figure 66). This option was designed to improve contextualization. If more than one web content is available for a specific video, clicking the web content icon will transport viewers to the 'webcontent' functionality, where the list of related web contents will appear highlighted within the complete list of available web contents.
- **Editing -** in the second generation, the possibility to edit and delete web contents, topics or even simple paragraphs was designed and implemented. Now, in the third generation, the interface was restructured in order to provide viewers with more **flexibility** and **personalization**. As novelties, viewers are now able to: move any piece of information (text, image, video, etc…) inside a web content and define privacy conditions to each piece of information. Both are achieved through the use of 'familiar' buttons considering that they were inspired on the MOODLE and Facebook (see Figure 67-b and 67-c). Viewers need to choose the option 'activate edition' and, from there, every time they approach a piece of information they are presented with the options: move, edit, delete, import and privacy.

Figure 66. Accessing contextualized video and web content

The ‘Import’ option may be internal or external. Internal refers to something inside the eiTV application, a piece of information from that specific web content or any other web content. External refers to something that comes from outside the eiTV application and thus may be a photo, a video, a sound file, SMS, MMS, etc (depending on the device being used).

For the ‘privacy’ option, a high level of **granularity** was made available: the viewer may define which web contents, or inside the web contents which tab, or inside a specific tab which pieces of information, are supposed to be visible. Viewers are presented with the following privacy options: Public, Friends, Me and Personalize (see Figure 67). On the ‘Personalize’ option, it is necessary to input friends e-mail addresses. This type of options, are available on facebook for each post, meaning that this is familiar for many viewers. This option provides higher flexibility to the application without raising too much its complexity, by taking the best advantage on familiarity.

In low fidelity prototypes this option was the one that caused more hesitations, namely, when importing pieces of information from other web contents to specific tabs. In many cases, the evaluator had to help in order to overcome the hesitation. It is true that it requires a higher number of steps but due to the flexibility that it provides to the application it was implemented in high fidelity prototypes. We were convinced that it was one of those cases which requires a little more practice but, sooner or later, will be adopted.

Figure 67. Web Content Privacy Options

a) On the web content, the viewers select 'Activate Edition'; b) Pressing the phone button will open the main popup menu. The viewer chooses one option, in this case 'privacy', which will open the correspondent menu (presented in c); c) The viewers choose the desired piece of information and then choose the desired 'Privacy' option from the menu.

Different levels of interactivity were made available; on the search functionality, a specific location may be inserted through text or through the GPS of the mobile device; photos or videos (stored or captured at that time) may be inserted as additional information to a web content at any moment. This additional information may be just sent to 'MyInput', a generic web content place where all inputs go by default, or immediately inserted on a specific location within the web content thus providing support for **flexibility** in the **personalization, contextualization** and support to different **cognitive modes.** In fact, viewers may simply send something important or urgent to 'MyInput' tab and later change that content to its appropriate place, or do it immediately depending on their cognitive mode at the time. As to all additional information, it appears in the web content with a different color (grey), when compared with the original content generated by the application (in white), thus helping to immediately identify manual personalization and thus **contextualization**.

4.4.2.3.6. Notification and Sharing

In the second generation, it was possible to generate a web content and share it with friends who were notified about the link to that web content via e-mail. That notification was just sent in the moment of the web content sharing. Now, an automatic functionality was designed and implemented to provide broader information to viewers friends and keep them up to date about updates on later editions. Let's imagine the following scenario: a viewer generates a web content and shares it with three friends. Those friends will be notified, via e-mail, about the web content link. One week later, if the viewer decides to import some files to that particular web content, or changes it in any way, the three friends will be automatically notified about those changes via e-mail. This functionality intends to improve the application **flexibility** and also **personalization** (considering that this automatic functionality may be turned off). We tried not to increase complexity by taking the best advantage on familiarity in the design of this functionality, since this automatic notification is much similar to what happens in Linkedin or Facebook, and at least for those with higher technological literacy it is not a novelty. To those with lower technological literacy it is almost unnoticeable, considering that it has to be selected.

4.4.3. Evaluation

Just like it happened in the other two generations, prototypes were evaluated through low and high fidelity prototypes and using the same evaluation framework as presented next.

4.4.3.1. Evaluating the Low-Fidelity Prototypes

The low fidelity prototypes, were evaluated using: the **expert usability evaluation** (this time with 8 experts: the same group from the second generation evaluation and 3 additional HCI experts); a **viewer usability evaluation** with the participation of 30 persons, namely, 10 students from ISMD, Information Systems Management Degree - with high technological literacy: 5 that already participated on the previous evaluation and 5 new ones; 10 students from MKTD (Marketing Degree) with less technological literacy: 5

that already participated on the previous evaluation and 5 new; 10 persons from the general public with low technological literacy: 5 that already participated on previous evaluation and 5 new. The decision about using previous and new evaluators in all the literacy groups was based on the assumption that with the experienced ones we would get richer insights about the implemented improvements in terms of interfaces, functionalities, how easy it is to learn how to use the application, etc. With the new ones, it is possible to perceive the application first impact with all the functionalities already implemented.

The script of tasks used in the viewer usability evaluation is presented in Annex L. After the usability evaluation, an **affective evaluation** (with experts and viewers) was conducted. In order to improve clarity, the results obtained were being presented along section 4.4.3. in order to justify design choices for the high fidelity prototypes. Nevertheless, the more important are presented next:

Some preferences and usability problems were identified in this early evaluation phase, as for instance:

- The icon to use in order to minimize the eiTV application to a small icon without logging out eiTV was chosen during this evaluation and all viewers agreed that using this approach was more intuitive;
- Two proposals were presented which comprised, amongst other things, two options for accessing the popup menu presented in Figure 58-c through a specific button designed in the interface, or through the 'menu' own mobile phone typical button. 70% preferred the second option. As to the presentation of found related videos and images, Figure 58-d, two proposals in order to differentiate videos from images were made: play button bellow or embedded in the video thumbnail. The last was chosen (77%). The icons presented in the popup menu were also validated with very good results. In terms of usability, the option menu presented in Figure 58-a was considered very good;
- In general, all interfaces related to the options: add metadata, search by metadata, search by GPS and export to eiTV, were considered very good and quickly understood by viewers;
- Some hesitation was observed when using the option 'Other files' from the DF options main list. This option allows exporting other files, other than video and photos, to a specific web content. In order to try to overcome these

difficulties it was decided to include detailed instructions in the interface (Figure 62-b);

- As to the ‘Extra topics’, feature some adjustments were made to improve usability. For e.g., two interfaces were tested, one presenting the complete list of topics (the chosen option) and another only with the extra topics. Viewers argued that the inclusion of all topics on the list was better, considering that all the possibilities would be presented at any moment, providing them with more flexibility. Thus being, this solution was implemented;
- The web content editing option was the one causing more hesitations, namely, when importing pieces of information from other web contents to specific tabs. In many cases, the observer had to help in order to overcome the hesitation. It requires a higher number of steps but, due to the flexibility that it provides to the application, it was implemented in the high fidelity prototypes.

In general, there was no substantial difference in opinion amongst the 3 groups. Nevertheless, it was possible to observe that the group with poor technological literacy, in general, took more time to accomplish the proposed tasks and asked more questions. However, like the other 2 groups, they all made it and the enthusiasm was the same. Interesting to note, no considerable differences were detected between the group with high technological literacy and the group with average technological literacy. This may be explained by the fact that they add already participated on previous evaluations of the eiTV, so they were probably becoming more familiar with it.

As to the affective dimension, the evaluation revealed that the majority of viewers felt pleasure (87%), arousal (80%) and ‘in charge’ (67%) while using the prototypes. In relation to the HQ scale, the values obtained for 1, 2 and 3 rating scale, for each pair of adjectives, were the following: outstanding (73%), exclusive (87%), impressive (80%), unique (87%), innovative (87%), exciting (87%) and interesting (87%) which were very positive results and better than the ones achieved with the first and second generation prototypes.

4.4.3.2. Evaluating the High-Fidelity Prototypes

The high fidelity prototypes were evaluated with the following tools and order: **evaluation sessions**, where they were asked to use all devices and available functionalities (see the viewer task-based script in Annex L and the evaluator grid in Annex E). The evaluation sessions were preceded by a demonstration of the last tested high fidelity prototype (the one from the second generation) in order to remind users and to create a sense of unity of the whole application, **questionnaires** (see Annex M), **interviews** (see Annex N) and **focus groups** with the participation of 30 persons (the same group from the low fidelity prototypes evaluation). The group of experts only participated in the evaluation sessions (in what refers to high fidelity prototypes) and, as on previous generations, their feedback was not included in the presented results.

In the evaluation session, viewers were asked to use all devices and all the available functionalities.

The evaluation results are presented next. More information, than on previous prototypes, is being presented considering that it was the last prototype being evaluated and that it was the one with more functionalities, features and options to evaluate. Considering that some dimensions were similar to the way they were in the second generation, where good results were achieved, the results presented here are more detailed on what was different in this generation.

4.4.3.2.1. Interfaces

The interfaces were divided in two categories: 'departure interfaces' and 'arrival interfaces'. Departure interfaces refer to all the interfaces that are used to generate the web content (independently of the device being used). Arrival interfaces refer to all the interfaces that are used to access the generated web content (independently of the device being used). The results of both, departure and arrival, interfaces evaluations are presented in Table 15 .

Table 15. Evaluation of eiTV overall departure and arrival Interfaces

(The percentages refer to the highest results: levels 4 and 5 of the 1-5 Likert scale used in the questions)

eiTV Crossmedia Application		**Easy to learn**	**Visually pleasant**	**Well designed**	**Could be better**
Departure Interface:	TV	73%	87%	73%	87%
	PC	80%	83%	80%	70%
	Mobile	93%	73%	60%	87%
Arrival Interface:	TV	63%	70%	67%	90%
	PC	87%	87%	80%	67%
	Mobile	93%	80%	73%	87%

In terms of departure interface: TV was considered the least easy to learn and the most visually pleasant. The mobile interface was considered the easiest to learn but the least visually pleasant and the least well designed. These results are very interesting, considering that their perception of visual pleasure did not influence their opinion on the easiness to learn and vice versa. PC was considered the best in terms of design, in spite of not being the easiest to learn or the most visually pleasant.

In terms of arrival interface: the TV was considered the least ease to learn, the least visually pleasant, the least well designed and the one that could be better (Figure 68). The PC was in average considered good in all dimensions. The mobile was considered the easiest to learn but the least well designed.

These results seem to indicate that further work needs to be done in what relates to the TV interfaces, nevertheless they support RQ1-b.

Figure 68. Viewer using the TV to access web content

In terms of information levels, only available on the departure interfaces, the results are presented in Table 16:

Table 16. Evaluation of eiTV overall departure interface (Information Levels)

eiTV Crossmedia Application		Most used information level		
		1	**2**	**3**
Departure Interface:	TV	47%	40%	13%
	PC	37%	43%	20%
	Mobile	50%	33%	17%

In terms of information level, in total more viewers preferred level 1 information (the least intrusive and least informational) when watching video. Nevertheless, is was interesting to see that from TV the difference between level 1 and 2 was only 7% and that, from PC, more viewers preferred level 2 and it was the device with more viewers preferring level 3, and that from mobile the big majority preferred level 1. These results were good and may indicate that the video viewing conducted to changes in cognition modes that were well supported through an interface from TV and PC with more additional information for a more reflective cognitive mode. As to mobile viewers, the majority preferred to select additional info to access later, in order not to interrupt the more experiential mode, considering that they were watching video on the move. These results support RQ1-a.

As to the different devices interfaces in general terms the results are presented next:

- **iTV Interfaces** - the results of the iTV interface are presented next (in accordance with the type and order of the questions within the questionnaire – Annex M).

When asked about how easily users adapted to the iTV interface: 10% answered normally, 33% with some facility and 40% very easily. This was a good result if considering that, in total, 83% of viewers adapted without major problems. These results support RQ1-b in relation to iTV interfaces.

In what relates to the easiest functionality from iTV, 43% answered ‘Create, 30% answered ‘Home’ and the other 27% answered ‘Profile’. This was a good result if considering that the Create functionality, which is the basis of this work, appears in first place. These results support RQ3 and belief that the iTV remains the preferred device to watch video.

In what relates to the most difficult functionality from iTV, 50% answered ‘Webcontent’, 27% answered ‘Share’, and 23% answered ‘Search’. These results were somehow expected and are coherent considering that, from all the devices the iTV is probably the less intuitive and natural to browse websites. Nevertheless some work needs to be done in order to try to improve this interface. These results support RQ1-b.

The global results in terms of iTV interfaces are presented next in Table 17. In global terms, the results were good and better than the ones achieved to the mobile phone interface. Nevertheless, we believe that better results may be achieved in terms of ease of use and fluid navigation and thus an effort should be done in order to improve these values.

When asked if the interface could be better: 20% answered that nothing could be better; 60% answered that little things could be better; 17% answered that average things could be better and only 3% (1 person) considered that many things could be better. When asked for suggestions he said "the interaction, is difficult when to use the web content". In general terms the results were very good.

Table 17. iTV interfaces evaluation

	Nothing	Little	Average	Much	Very Much
Is Intuitive	0%	10%	23%	30%	37%
Is easy to use	0%	13%	24%	30%	33%
Has a fluid navigation	0%	3%	30%	40%	27%
Is visually pleasant	0%	0%	16%	37%	47%
Uses easy to understand keys	0%	0%	20%	33%	47%
Adapts to viewer needs (providing more or less information)	0%	0%	10%	17%	73%
Is not intrusive and does not distract from essential	0%	0%	23%	40%	37%
Works well with the use of a MENU-based system	0%	0%	7%	33%	60%
Could be better	20%	60%	17%	3%	0%
Is well designed	0%	0%	20%	30%	50%

- **PC Interfaces** - the results of the PC interface are presented next (in accordance with the type and order of the questions within the questionnaire - Annex M).

When asked about how easily users adapted to the PC interface: 17% answered normally, 33% with some facility and 50% very easily. This was a good result if considering that, in total, 100% of viewers adapted without major problems. These results support RQ1-b in relation to PC interfaces.

In what relates to the easiest functionality from PC, 47% answered ‘Webcontent’, 33% answered ‘Home’ and the other 20% answered ‘Profile’. This was a good result considering that the ‘webcontent’ functionality was considered the easiest (specially taking into account that it was found to be the most difficult when used from iTV). These results support RQ3.

In what relates to the most difficult functionality from PC, 40% answered ‘DF’, 33% answered ‘Search’, and 30% answered ‘Share’. These results were good considering that the ‘Create’ functionality was not mentioned and that the most difficult was the ‘DF’ functionality, a coherent result considering that it was tested for the first time. These results support RQ1-b.

The global results in terms of PC interfaces are presented next in Table 18.

In global terms, the results were very good when compared to the other interfaces.

When asked if the interface could be better: 47% answered that nothing could be better; 37% answered that little things could be better and 16% answered that average things could be better. When asked for suggestions only one viewer said that “is strange to use the create functionality from the PC”. The lack of concrete suggestion was also a good indicator. In general terms the results were very good.

Table 18. PC interfaces evaluation

	Nothing	Little	Average	Much	Very Much
Is Intuitive	0%	0%	20%	33%	47%
Is easy to use	0%	0%	13%	37%	50%
Has a fluid navigation	0%	0%	20%	37%	43%
Is visually pleasant	0%	0%	7%	27%	66%
Uses easy to understand buttons	0%	0%	10%	37%	53%
Adapts to viewer needs (providing more or less information)	0%	0%	3%	17%	80%
Is not intrusive and does not distract from essential	0%	0%	10%	33%	57%
Works well with the use of a MENU-based system	0%	0%	3%	17%	80%
Could be better	47%	37%	16%	0%	0%
Is well designed	0%	0%	7%	33%	60%

- **Mobile Phone Interface** - mobile phone interfaces, which were implemented in high fidelity prototypes for the first time in the third generation, achieved the results presented next (in accordance with the type and order of the questions within the questionnaire - Annex M).

When asked about how easily users adapted to the mobile device interface: 27% answered normally, 33% with some facility and 10% very easily. This was a good result if considering that, in total, 70% of viewers adapted without major problems. These results support RQ1-b in relation to mobile interfaces.

In what relates to the easiest functionality from mobile phone, 53% answered 'Home', 23% answered 'Create' and the other 23% answered 'Profile'. This was a good result if considering that the Create functionality, which is the basis of this work, appears in second place. These results support RQ3.

In what relates to the most difficult functionality, 30% answered 'DF', 27% answered 'Share', 23% answered 'Search' and 20% answered 'Webcontent'. These results were in fact good and better than expected. To have the DF functionality classified as the most difficult was somehow expected, considering that this functionality was new to all viewers and never tested before. However, we expected a higher distance in terms of percentage when compared to the other functionalities values and 'DF' had 30% while 'Search' (an already tested functionality) had 27% (only 3% lower). On the other hand the results achieved with the 'search' functionality improved in relation to previous generation. These results support RQ1-b.

The global results in terms of mobile interfaces are presented next in Table 19.

In global terms, the results were good. Nevertheless, the values achieved with the first three questions were already expected, taking into account that these interfaces were implemented in high fidelity for the first time and that, in specific functionalities as the ones related to the web content use, the interface resulted a bit too loaded mainly due to the small size of the screen. Thus being, an effort should be done to improve these interfaces in order to be more intuitive and easy to use.

Table 19. Mobile phone interfaces evaluation

	Nothing	Little	Average	Much	Very Much
Is Intuitive	0%	13%	20%	40%	27%
Is easy to use	0%	10%	23%	27%	40%
Has a fluid navigation	0%	10%	27%	30%	33%
Is visually pleasant	0%	0%	20%	37%	43%
Uses easy to understand buttons	0%	0%	23%	40%	37%
Adapts to viewer needs (providing more or less information)	0%	0%	7%	13%	80%
Is not intrusive and does not distract from essential	0%	3%	30%	40%	27%
Works well with the use of a MENU-based system	0%	0%	13%	30%	57%
Could be better	13%	54%	23%	3%	0%
Is well designed	0%	0%	23%	30%	47%

When asked if the interface could be better: 13% answered that nothing could be better; 54% answered that little things could be better; 23% answered that average things could be better and only 10% (3 persons) considered that many things could be better. When asked for suggestions one said “everything in general”, one said “the DF in general is very complicated” and the third said “mainly the create functionality and things related to the use of the web content, in my opinion the screen has too many things”.

In general terms, and considering that it was the first time that this interface was tested in high fidelity prototypes the achieved results were very encouraging.

4.4.3.2.2. Functionalities

Three functionalities were tested: Device Functionalities (DF) because it was tested on high fidelity for the first time, Webcontent and Create because they were improved with extra features. In what refers to each of these three functionalities, viewers were asked about the level of interest, level of difficulty, about their overload in terms of mental, physical, temporal, performance, effort and frustration while using the functionality. Finally, and in global terms, they were asked about the functionality usefulness, ease of use, ease of learning and satisfaction (see the questionnaire in Annex M, constructed based on the direction proposed in section 3.4.4.3.).

4.4.3.2.2.1. Device Functionalities

As to the level of interest on each of the functionality options, the results were a good surprise considering that six (out of fourteen) available options caught the attention of 100% of viewers, as may be seen in Table 20.

Table 20. 'DF' functionality: levels of interest and difficulty

(The percentages refer to the highest results: levels 4 and 5 of the 1-5 Likert scale used in the question related to the level of interest and to levels 1 and 2 of the 1-5 Likert scale in the question related to the level of difficulty)

Device Functionalities (DF) options	**Level of Interest (some interest + interesting)**	**Level of Difficulty (easy + very easy)**
Minimize the eiTV application without exit	*100%*	100%
Add GPS coordinates to Myinput tab or specific webcontent	97%	87%
Synchronize devices	*100%*	93%
Use videos (from the gallery or recorded at that moment) in order to:		
a) Add metadata	93%	93%
b) Search by metadata (content-based search)	96%	83%
c) Search by GPS (location-based search)	*100%*	97%
d) Export to eiTV	*100%*	93%
Use pictures (from the gallery or taken at that moment) in order to:		
a) Add metadata	96%	90%
b) Search by metadata (content-based search)	90%	80%
c) Search by GPS (location-based search)	*100%*	97%
d) Export to eiTV	*100%*	97%
Import other files to the eiTV, namely:		
a) Audio files	90%	87%
b) SMS	73%	83%
c) MMS	84%	90%

When asked about their opinion on the manual introduction of metadata to classify pictures and videos (something that they were asked to do, see Annex L) 73% answered that it was ok, 20% answered that it is acceptable considering that they are very used to writing sms, and 7% answered that it was better to have that option available automatically (the ones with more technological literacy). In our opinion, the high number of students not claiming for automation (93%) is due to the fact that they are not used to this type of automation but more to the flexibility associated with personal classification as usual on youtube, Flickr, etc. In fact, and as some of them said: when text is supposed to be used, it is supposed to be written through keywords. Nevertheless, both options are complementary and should be implemented. The presented results support RQ1-a), b), c); RQ2 and RQ3.

In what relates to viewers overload in terms of mental, physical, temporal, performance, effort and frustration while using the functionality the detailed results are presented in Table 21.

Table 21. 'DF' functionality: cognitive overload

(The percentages refer to the lowest results: level 1 which corresponds to 'nothing' and level 2 which corresponds to 'little'. It was a 1-5 Likert scale)

Overload	**Answers (nothing + little)**
How mentally demanding were the tasks?	50%
How physically demanding were the tasks?	76%
The temporal effort I had to do in order not to take too much time	50%
How hard did I have to work to accomplish my level of performance?	63%
How insecure, discouraged, irritated, stressed and annoyed was I?	80%

The results were good considering that we are counting the values from levels 1 and 2 of a Likert scale, taking into account that these questions refer to negative aspects. Level 3, which means acceptable or average, is not presented in the table. In the case of the first question, on how mentally demanding the tasks were, 43% of viewers answered the level 3 value (meaning average) and only 7% considered the tasks very mentally demanding. The same happened with the temporal effort, where level 3 achieved a value of 40% with only 10% considering the task temporal effort high. Concluding, all the results achieved were considered good even those related with the mental demanding and temporal effort, with 50%. In fact, it is acceptable and even expected that a new application, with different types of functionalities and requiring the use of different devices, needs more mental effort and time to be completed.

When asked about their performance, how successful they were accomplishing the assigned tasks, 27% answered high and 63% answered very high. The results support RQ1-b.

Finally, and in global terms, they were asked about the functionality usefulness, ease of use, ease of learning and satisfaction. The results, presented in Table 22, were considered very rewarding and far beyond our expectations. Even ease of use, the lowest (77% of 4-5) may be considered good. The results RQ1-b, RQ2 and RQ3.

Table 22. 'DF' functionality: global evaluation

	Nothing	Little	Average	Much	Very Much
Useful	0%	0%	3%	17%	80%
It covers my needs	0%	0%	10%	37%	53%
Is easy to use	0%	0%	23%	40%	37%
Is flexible	0%	0%	10%	23%	67%
Is easy to learn how to use	0%	0%	13%	57%	30%
I'm satisfied for having it	0%	0%	0%	13%	87%
Available features interesting	0%	3%	20%	27%	50%

4.4.3.2.2.2. Webcontent

The options in this functionality 'Webcontent' were also implemented and tested for the first time.

As to the level of interest on each of the functionality options, the results were a good surprise considering that seven (out of eleven) available options caught the attention of 100% of viewers (Table 23).

Table 23. Webcontent functionality: levels of interest and difficulty

(The percentages refer to the highest results: levels 4 and 5 of the 1-5 Likert scale used in the questions)

Features	Level of Interest (some interest + very interesting)	Level of Difficulty (easy+ very easy)
To see the list of webcontents	100%	93%
To delete webcontents	100%	90%
To share webcontents	97%	83%
To enter the webcontents	100%	100%
To merge webcontents	57%	100%
To see the webcontent source video	100%	100%
To move pieces of information	87%	73%
To edit pieces of information	100%	93%
To delete pieces of information	100%	100%
To import internal and external information to the webcontent	83%	80%
To define different privacy status for each piece of information	100%	100%

In contrast, the option to merge contents seems to be interesting to 57% of viewers. As to the level of difficulty, the results were very good. Interesting to see that in spite of not being so much interested in the merge option, 100% of viewers found it easy to use. Thus is going to be maintained. These results support RQ1-b.

Results concerning their mental, physical and temporal overload, performance, effort and frustration while using the functionality are presented in Table 24.

When asked about their performance, how successful they were accomplishing the assigned tasks, 27% answered high and 53% answered very high.

When compared to the results of the overload DF functionality, these results are considerably better, which may be explained by different factors: there are less available options (eleven against fourteen), some of these options work pretty much like the Facebook ones in what relates to managing small blocks of information (in fact, Facebook was part of our inspiration in terms of options and design, in order to take advantage on familiarity), this functionality interface works pretty much like a website interface (double clicking to follow a link, information organized in tabs, links underlined, etc.).

Table 24. Webcontent functionality: cognitive overload

(The percentages refer to the lowest results: level 1 which corresponds to 'nothing' and level 2 which corresponds to 'little'. It was a 1-5 Likert scale)

	Results from answers: nothing + little
How mentally demanding were the tasks?	64%
How physically demanding were the tasks?	84%
The temporal effort I had to do in order not to take too much time	64%
How hard did I have to work to accomplish my level of performance?	77%
How insecure, discouraged, irritated, stressed and annoyed was I?	73%

Finally and in global terms, they were asked about the functionality usefulness, ease of use, ease of learning and satisfaction. The results presented in Table 25 were considered very good. These results support RQ1-b),c) and RQ2.

Table 25. Webcontent functionality: global results

	Nothing	Little	Average	Much	Very Much
Useful	0%	0%	17%	33%	50%
It covers my needs	0%	0%	10%	43%	47%
Is easy to use	0%	3%	7%	60%	30%
Is flexible	0%	0%	7%	56%	37%
Is easy to learn how to use	0%	3%	11%	53%	33%
I'm satisfied for having it	0%	0%	0%	13%	87%
Available features interesting	0%	3%	27%	37%	33%

When compared to the results of the DF functionality the ease of use was superior (90% webcontent against 77% DF), which is consistent with the better results for the cognitive overload obtained with the web content. Nevertheless, viewers were more enthusiastic with the DF functionality than with the web content new features, probably meaning that is just a question of time.

4.4.3.2.2.3. Create

In what relates to the 'Create' functionality, two new options were made available to all devices. Now the possibility to choose topics of interest, beyond the ones prepared by the application, was made available and was named 'extra topics'. In the second novelty, by default, the application sends an e-mail to those that have received generated web contents, every time that web content is edited (this option keeps them up to date and was inspired on Linkedin and Facebook). Tested was the deactivation of this option. As to the extra topics option, 90% of viewers considered it interesting and 66% considered it easy to use. As to the option of sending e-mails automatically, only 54% of viewers considered it interesting and 57% considered it easy to use (in this particular case, easy to deactivate since it is activated by default).

In what relates to mental, physical and temporal overload, performance, effort and frustration while using the functionality, the obtained values are very close to the ones presented about the webcontent functionality, thus not presenting any situation that needs a specific explanation.

Finally, and in global terms, they were asked about the functionality usefulness, ease of use, ease of learning and satisfaction. The results, presented in Table 26, were considered good taking into account that they were evaluating two different options (extra topics and sending automatic notifications by e-mail) with very different levels of interest (respectively 90% and 54%).

Table 26. Create functionality: global results

	Nothing	Little	Average	Much	Very Much
Useful	0%	0%	27%	33%	40%
It covers my needs	0%	0%	20%	33%	47%
Is easy to use	0%	10%	30%	*27%*	*33%*
Is flexible	0%	3%	10%	37%	50%
Is easy to learn how to use	0%	3%	4%	*60%*	*33%*
I'm satisfied for having it	0%	0%	13%	27%	60%
Available features interesting	0%	7%	37%	33%	23%

The ease of learning result (93%) was very good and higher than the ease of use (60%). This difference did not occur in the other two functionalities, possibly meaning that it is not as easy at first, but easily learnt along its use. These results support RQ1-a), b), c) and RQ2.

4.4.3.2.3. eiTV as a whole in crossmedia

The eiTV final application was evaluated in terms of usefulness, ease of use, ease of learning, satisfaction, continuity, contextualization, cognitive overload, etc. (questionnaire presented in Annex M).

In what refers to the **usefulness** of the eiTV application in global terms, the results were really good (Table 27). The more relevant results were the following: to 100% of viewers the application helps them be more productive when watching the video; it is useful and gives them more control over the information that they watch on video. Also 100% of viewers like to be able to access their eiTV application and its functionalities from any device and 100% like the flexibility that the application provides. These results answer positively RQ1-b, RQ2 and RQ5.

In what refers to the **ease of use** of the eiTV application in global terms, the results were also very good (Table 28) considering the amount of devices, functionalities, options and contexts involved. These results answer positively our RQ1-b.

Table 27. Final eiTV application: usefulness

	Nothing	Little	Average	Much	Very Much
It helps me be more effective	0%	0%	13%	17%	70%
It helps me be more productive when I watch video	0%	0%	0%	*23%*	*77%*
It is useful	0%	0%	0%	*20%*	*80%*
It gives me more control over the information that I watch on video	0%	0%	0%	0%	*100%*
It makes the things I want to accomplish easier to get done	0%	0%	10%	*30%*	*60%*
It saves me time when I use it	0%	0%	20%	23%	57%
It meets my needs	0%	0%	3%	37%	60%
It does everything I would expect it to do	0%	0%	10%	*33%*	*57%*
It comprises very useful functionalities	0%	0%	7%	33%	60%
I like to be able to access my eiTV application and its functionalities from any device	0%	0%	0%	0%	*100%*
I like the flexibility that the application gives me: now I can use it through the TV at home, later I continue through the smartphone on my way to school, etc	0%	0%	0%	*3%*	*97%*

Table 28. Final eiTV application: ease of use

	Nothing	Little	Average	Much	Very Much
It is easy to use	0%	3%	20%	20%	57%
It requires the minimum of steps to do what we want to do	0%	0%	3%	37%	60%
It is flexible	0%	0%	0%	20%	80%
Using it is effortless	0%	10%	20%	33%	37%
I can use it without written instructions	0%	0%	13%	47%	40%
I didn't notice any inconsistencies as I use it	0%	0%	3%	60%	37%
Both occasional and regular users would like it	0%	0%	17%	23%	60%
I can recover from mistakes quickly and easily	0%	0%	0%	27%	73%
I can use it successfully every time	0%	0%	23%	50%	27%

In what refers to the **ease of learning** of the eiTV application in global terms, the results were good (Table 29). In particular, three of the presented values are especially interesting: 97% of viewers easily remember how to use the application, while 84% learned to use it quickly, and only 57% quickly became skilful with it. At first sight, these may look inconsistent results, but learning to use something quickly means quickly understanding the conceptual model behind it, which does not necessarily mean to master it right away. Thus, it is normal to have a low percentage of viewers that quickly become skilful with the application. Becoming skilful comes with practice. These results positively answer RQ1-b and RQ5.

Table 29. Final eiTV application: ease of learning

	Nothing	Little	Average	Much	Very Much
I learned to use it quickly	0%	0%	16%	*47%*	*37%*
I easily remember how to use it	0%	0%	3%	*37%*	*60%*
It is easy to learn to use it	0%	0%	17%	43%	40%
I quickly become skilful with it	3%	10%	30%	*43%*	*14%*
The interfaces are intuitive	0%	7%	20%	33%	40%

In what refers to **satisfaction** with the eiTV application in global terms, the results were very good (Table 30). All viewers want to have the application and would recommend it to friends. These results answer positively RQ1-a, RQ1-b, RQ2 and RQ5. Some interesting commentaries were registered, namely: “this is awesome, my brother will just love it”, “the GPS functionality was very cool, I had no idea that it could be used like this”, “I really appreciated the possibility to personalize my web contents at any time with information from different sources” (from students with high technological literacy); “this is much cooler than the new X service” <being X a cable service provider>, “I really enjoyed the idea, truly! Is this going to be available soon?”, “When I watch TV I really hate the commercials between movies, this would be so cool… I could access web contents while waiting for the movie to start again” (from students with less technological literacy) and “I like the sensation of power that information level 2 provides me… this means that no longer I will miss information because I can ask about everything that I didn’t understand”, “this is a good tool for my fourteen year old soon, he is lazy in relation to school and he spends hours watching TV. With this he may watch TV and prepare specific web contents that he would like to use because he also spends hours watching websites, this is a clever disguised learning tool!”, “it was a surprise use the smartphone at the same time than TV to see related information with more detail, I didn’t know I could use a smartphone connected to the TV with this purpose” (from the group of viewers - non students - with lower technological literacy).

Table 30. Final eiTV application: satisfaction

	Nothing	Little	Average	Much	Very Much
I am satisfied with it	0%	0%	4%	13%	83%
I would recommend it to a friend	0%	0%	0%	*7%*	*93%*
It is fun to use	0%	0%	13%	20%	67%
It works the way I want it to	0%	0%	10%	40%	50%
It is awesome	0%	0%	23%	37%	40%
I would like to have it	0%	0%	0%	*10%*	*90%*
It is good to use	0%	0%	14%	33%	53%

When asked if there is a real advantage in **connecting** these 3 **devices**, all the viewers answered Yes (answers positively RQ2). From a presented list of motives that they were asked to enumerate, the results were the following (presented by order): They provide us with mobility; They provide us with flexibility; This type of application is a novelty; We may access extra information about a video; It is interesting to have the TV connected with other devices; It is fun. This means that they perfectly understood how far the application provides them with **mobility** and **flexibility** besides being a new approach and paradigm.

When asked if, when accessing the portal through different devices, they had the immediate sensation of being in the same application, all viewers answered Yes (answers positively our RQ1-a). Some of the presented motives were: “they have a familiar look”, “they use the same colors and options”, “I’m used to accessing Facebook through PC, mobile phone and tablet”, “everything is pretty much similar”, “I don’t know how to explain, but I knew”. Then they were asked about having different available options depending on the device being used. When asked if it was confusing, 93% answered no. When asked if it was interesting, 97% said yes, and when asked if it makes sense, 100% said yes. These questions allowed us to evaluate **continuity** and to see that it clearly succeeded.

As to the 15 viewers that already participated in previous prototypes evaluations, they were asked to compare this version with the previous ones. When asked if this version is easier to learn in spite of implying the use of more devices and functionalities, and from the list of available answers: 14% chose I agreed, 33% more or less, 33% slightly disagree and 20% strongly disagree. These results were not exactly a surprise, it is obvious that this version is more demanding in terms of effort, cognitive load, etc. But in spite of being considered more difficult to learn, it was considered more intuitive (73%), more user friendly (87%), more flexible (**100%**), with better interfaces (86%), more pleasant for the viewer (**100%**) and has more functionalities (**100%**). Also comparatively to the previous eiTV prototype: **100%** agreed that the new functionalities contributed to improve the eiTV application, 93% agreed that the **contextualization** was better achieved (due to the use of excerpts of the video playing, from few seconds before the moment of the topic choice), 93% agreed that the **continuity** was better achieved, **100%** agreed that the use of a unique portal where all the web contents are aggregated was a good idea, and **100%** agreed that it is good to be able to use, through the mobile phone, all the functionalities that were available through the TV and PC (**flexibility**).

In relation to the viewers groups, and as expected, some differences were noticed. The group with less technological literacy was the one that needed more time and support to accomplish the tasks (in particular the use of the search and DF functionalities and the personalization of the web content). As to many of the other functionalities and tasks the difference between this group and the average technologic literate was practically unnoticeable. In relation to the satisfaction with the eiTV application the results were pretty much the same amongst the three groups meaning that, in spite having different technological literacy, taking different times to accomplished tasks and having different preferences in terms of functionalities they were equally committed to the application. In fact, to the group with less technological literacy, the preferred functionalities were: the ones directly related to generate the web content, access it and using devices simultaneously. To the group with higher technological literacy the preferred functionalities were the ones associated to the create, share and search functionality, they highly appreciated the simultaneous use of devices, the possibility to personalize the web contents specially the confidentiality with a high level of granularity and the possibility to use GPS coordinates in order to search related contents.

As to the remaining research questions:

RQ3*: What are the preferred interface designs for the relevant cognitive modes and needs in each scenario? Along the several options and functionalities, which interfaces work best to support the different cognitive modes (experiential and reflective) and levels of attention?*

We strongly believe that the preferred interface designs were, pretty much, the implemented ones. The results on the interfaces evaluation were much better than expected considering that, even after the evaluation of several prototypes, some of the viewers have low level of technological literacy and thus are not used to these interaction levels. However, they still preferred: information levels 1 and 2 instead of 3, in spite of agreeing about the importance of having different levels in order to accommodate different cognitive modes, goals and needs. Viewers still preferred embedded rather than overlay on information levels 2 and 3, but they liked to have both options available since they provide them more control and flexibility. They preferred to have the video playing in all functionalities: when on levels 2 and 3 from the create functionality, when searching videos and when accessing the generated web content, but they appreciated being able to pause the videos in order to accommodate changes in cognition modes and for flexibility. An interesting discovery was that, in spite of not adopting chromatic keys in previous evaluations, now they were more comfortable using them as shortcuts and started liking them. This feature provides them with more flexibility and accommodates different levels of technological literacy and more and less experienced users. Viewers prefer the topics ordered by the chosen order instead of alphabetically, but they recognize the advantage of having both options available. Few viewers found the merge web contents functionality interesting, which could be explained considering that in evaluation contexts they do not have time to accumulate different web content versions of the same video, the situation that usually benefits from the use of the merge functionality. Also few viewers found the automatic sending e-mail functionality interesting. This functionality is responsible for keeping web content receivers up to date on web content changes but, in an evaluation context, they did not have time to fully experiment this functionality. Nevertheless, mainly due to their experience using Facebook, they recognized the functionality utility.

***RQ4**: What other functionalities would viewers like to have in this kind of crossmedia environment, capable to generate extra web content to video?*

Five viewers suggested the use of an instant messaging functionality inside the eiTV application. Two viewers suggested the use of an automatic image and video annotation method instead of just inserting metadata manually, and one viewer with lower technological literacy suggested the possibility to use apps inside the iTV application, in order to allow viewers to have extended functionalities like being aware of friends birthday (like it happens on Facebook).

***RQ6**: Were the proposed frameworks, for crossmedia and iTV, adequate and efficient?*

Considering that the design and use of the eiTV application and iTV interface were, once again, conducted following the directions identified on both crossmedia and iTV conceptual framework, and that the achieved results were much better than the ones achieved with the first and second generation prototypes, we have reasons to believe that we were capable to identify critical points and possible solutions to the design of crossmedia and iTV applications in this context.

4.4.4. Discussion

The prototypes were designed and tested in realistic scenarios and contexts of use through TV, PC and mobiles. The evaluation results were truly encouraging. In many aspects, the increased functionalities and flexibility inherent to the mobile context were perceived as very useful and an added value in this crossmedia environment (e.g., location-based search and content-based search). Some design options allowed to accommodate viewers changes in cognition modes (e.g., information levels and types of information). In general, the results showed that the integration of the mobile devices in the eiTV environment was a success. The use of a high fidelity prototype with all functionalities and options available through all the devices was an excellent option. One may argue that the good results achieved rely on having viewers that participated on previous evaluation moments, thus gaining some experience. In fact, half of viewers already participated in other evaluation moments, but the other half were completely new, and the design interface, as well as the functionalities, evolved along generations providing new experiences. On the other hand, when comparing the evaluation results achieved from both groups (previous group with the new group) the differences were a lot less noticeable than expected, meaning that the ones that never saw the prototypes before, adapted with almost the same facility to all interfaces and functionalities. In general terms, it was a surprise to compare the results from the three levels of technological literacy. It was expected that the group with lower technological literacy would present some resistance and feel some difficulty in relation to more interactive functionalities. However, in spite taking a little more time to complete some tasks and need more support in order to do so, they were very enthusiastic and in many situations of use there was no difference between this group and the group with average technology literacy, meaning that they are not so technological skilful but they are equally interest and committed which is an excellent indicator.

4.5. Summary

This chapter describes the eiTV crossmedia video-based application, designed and developed to explore and illustrate the paradigm proposed in this thesis following the framework described in chapter 3, briefly presents the technical dimension related to the high fidelity prototypes development, and discusses the results achieved. However, the eiTV design process, which occurred iteratively, resulted in improved functionalities and changes into the conceptual model that were divided into three generations. Each generation presented specific prototypes developed in order to explore, illustrate and test the proposed conceptual model and functionalities. As to the **First Generation**, the conceptual goal was to explore the design of an application capable to generate, from iTV, personalized web contents as additional information to the program being watched, in response to informal learning opportunities, to be accessed through PC, TV or mobile phone. In the **Second Generation** there was a conceptual change based on a ‘beyond iTV’ desire as well as with the adequateness of a portal aggregator of all application functionalities. Thus, this generation is more aligned with the concept of video in the '***CLOUD'.*** Considering that, from a technological point of view, video can be watched anytime, anywhere, from different types of devices, the conceptual model evolved to the use of devices in a redundant fashion meaning that each device (TV, PC and mobile phone) may be used to the same functionalities: watch the video, generate the related web content and access it. Finally, and from a conceptual point of view, in the **Third Generation Prototypes** the keyword is ***MOBILE*** and the flexibility inherent of being mobile with the co-existence of different devices and contexts of use. The goals were to take the best advantage: from mobile phones, in terms of mobility and specific features and from their synchronization with other devices in a complementary way.

All generation prototypes, low and high-fidelity, were described in this chapter. Each design choice was explained and contextualized in relation to the crossmedia dimensions identified in the conceptual framework described in chapter 3. All prototypes were also evaluated following the crossmedia evaluation framework and iTV framework both described in chapter 3.

Concluding, considering the design frameworks followed, the trends in the use of multiple devices, and the results achieved from the three generation prototypes, we have reasons to believe that our goal for this eiTV crossmedia application was reached and that the identified crossmedia dimensions used to support and conduct the design of conceptual models, approaches and solutions, succeeded.

“*It’s faith in something and enthusiasm for something that makes a life worth living.*”
Oliver Wendell Holmes

5. Conclusions

This thesis main goal was to efficiently and flexibly, support users learning informal opportunities, created in video-based crossmedia environments, taking into account the different cognitive modes, contexts of use and taking advantage of the diverse devices being used in order to have each device contributing with what it does best. Video is a privileged medium in terms of communication, affect and cognition. It has the ability to trigger changes in cognition modes which, when properly supported through other media and devices, has the ability to accommodate different learning situations and contexts of use. Informal learning situations occurring through different types of devices, depending on viewers’ location and contexts, are becoming a reality and there is a need to take the best advantage and provide the best support for this. In practical terms, this refers to crossmedia applications and systems, which due to their novelty, increasing interest, and many advantages associated to their use, are becoming a focus of interest in several research areas. However, after a literature review, it was possible to perceive that too many proposed crossmedia applications and systems failed because too much effort was put into technical details, leaving behind crossmedia conceptual questions related to interaction design and underlying cognitive aspects, usability, affectivity, user experience, contextualization, continuity, media technology, or device characteristics. The handling of these dimensions when video is involved was our starting point and main motivation. In order to illustrate, explore and validate our research, the approach followed was to conceptualize, prototype and evaluate the eiTV application. In brief, the first eiTV version was capable to generate, from iTV, personalized web contents as additional information to the program being watched, in response to informal learning opportunities, to be accessed through PC, TV or mobile phones. At the beginning, the ‘departure point’ was solely iTV, considering that it still is the privileged device to watch videos. Next, the application evolved in order to work inside a portal which allowed that all devices could work as ‘departure points’, thus resulting in a crossmedia application where each one of the three devices in use (TV, PC and mobile phone) could be used to generate the web content and to access it. The last phase was the evolution of the application to allow synchronization, to accommodate second screen usage and be able to take the best advantage of each device specific features, as for e.g. the use of content-based search, and location-based search using mobile coordinates. All eiTV functionalities, features, options, interfaces, etc., were planned, designed, prototyped and evaluated in accordance with our research and the identified conceptual dimensions. The evaluation results were very encouraging in all evaluation phases and in relation to all the evaluated dimensions.

5.1. Contributions to Research

This thesis main contribution was the study and handling of the crossmedia conceptual dimensions which, after being gathered, were grouped in what we called crossmedia conceptual framework. Several high fidelity prototypes were designed and evaluated using the framework and they all succeeded receiving useful, constructive and very positive feedback allowing to identify main usability problems and least and most appreciated features. Thus we have reasons to believe that we were able to identify critical points and possible solutions to the analysis, design, prototyping and evaluation of crossmedia video-based applications.

This thesis second contribution was a consequence of the first contribution. In fact, the most used devices in crossmedia applications are TV, PC and mobile devices, meaning that our approach should include these devices. However, when the need to design, prototype and evaluate iTV interfaces arose, no specific iTV conceptual framework was available. Thus being, a group of conceptual questions that should be addressed, when iTV applications and services design and evaluation is the goal, were studied and grouped in an iTV conceptual framework.

This thesis third contribution was the eiTV application, a crossmedia video-based application capable to generate, from video, web contents with extra related information on the selected topics while watching the video. This application was developed in order to illustrate, explore and validate our research in terms of crossmedia conceptual questions, related to interaction design and underlying cognitive aspects, usability, affectivity, user experience, contextualization, continuity, media technology, or device characteristics. The application went through a long process of development. Conceptual model, Interfaces, functionalities, etc. evolved dramatically in order to allow testing the identified dimensions and the proposed design solutions to accommodate them. The identified dimensions were: cognitive modes, cognitive theory of multimedia learning design principles, heterogeneity, interoperability, consistency (perceptual, lexical, syntactical and semantic), continuity, contextualization, device redundancy, synergic use, crossmedia UI (distribution, migration, granularity, trigger activation type, timing and interaction modalities involved), usability, transparency, adaptability (also defined as plasticity), flexibility, user experience, coherence (in terms of perception), personalization and devices contexts of use (levels of attention, levels of TV viewing, affective dimension of TV viewing, goals and needs). We only stopped this work after achieving a solution with design options able to accommodate all the previously enumerated dimensions with good results from viewers evaluation and exploring the three types of device. In fact, we achieved a final eiTV that may be considered very good (taking into account the evaluation results achieved) and the viewer's enthusiasm about the application. Thus, more than an application to illustrate and test the study of crossmedia conceptual dimensions, we believe that this may set the basis for a very interesting service for further adoption through a cable TV operator.

This thesis fourth contribution were the publications which main goal was to validate and publicize the various concepts, ideas, contributions and results of the work presented in this thesis, to the Scientific Community.

5.2. Research Questions Analysis

In chapter 1, six research questions were raised. The achieved results along the three generations of prototypes designed to illustrate, explore and validate our research totally answered these research question and are explained in detail in the evaluation section of each generation. However, and in global terms a brief summary is presented:

RQ1*: Which model interface design and functionalities are adequate in order to:* ***a)*** *Provide an adequate support to create and follow extra web contents?*

In order to provide an adequate support to the creation of video-based web contents, different strategies were followed and designed in order to accommodate the conceptual dimensions identified.

The *create* interface was designed and made available: covering two types of information (content info and meta info), with three levels of information (from less to more informational), whit the possibility to choose more topics of interest than the ones presented by default in what relates to the content info, with two possible layouts (embedded and overlaid on screen), inside a portal (which allowed the access to the create functionality from any device and any other functionality), with a 'confirmation interface' where viewers access the complete list of topics in order to confirm or change them before generating the web content and, in order to generate the web content automatically if, accidentally, viewers turn off the device. These options were designed to accommodate different cognitive modes, goals, needs and heterogeneity of medium and contexts of use, and mainly to provide viewers with flexibility, continuity, usability, consistency, adaptability and transparency. Interfaces were also prepared to *follow* extra web contents through the following strategies: every time viewers create a web content, they are informed through e-mail, sms, or both (depending on their profile preferences) about the web content link. When a video with already generated web contents is being watched, an icon is presented in the top right corner of the screen allowing immediately and directly following those web contents (the inverse path was also made available, to watch a web content and be able to follow, via an icon, the video that originated the web content). Two other functionalities also allow to easily follow the generated web contents (Search and Webcontent functionalities). Different possibilities were made available to follow the generated web contents, thus also being adequate to different cognitive modes and providing flexibility, continuity, usability, consistency, adaptability and transparency.

Concluding: considering the evaluation results on these functionalities, features and design options, which were being extended and improved throughout the generations, we may state that the designed interfaces were very efficient in order to support the creation and access to the web content.

RQ1*: Which model interface design and functionalities are adequate in order to:* ***b)*** *Have interfaces easy to use and understand in each of all devices (usability)?*

The adoption of a User Centered Design (UCD) approach, exploring different design options with evaluation carried on both low and high fidelity prototypes was important. All our interfaces were evaluated, amongst others, in terms of usefulness, ease of use, ease of learning, satisfaction and cognitive overload. This evaluation was carried on with a considerable level of granularity. In fact, these dimensions were evaluated at the functionality and feature level, to each device interface and, only at the end of the questionnaire, in relation to the eiTV prototype in general. Our evaluation process was very detailed but that certainly contributed to identify the good results achieved in the different aspects. In fact, the achieved prototypes, especially the ones from the last generation achieved unexpected results in a good sense. Viewers stated that, for e.g., the colors used, the type of graphical elements, the font type and size, the background color, and the images used through all UIs helped in creating an application with good usability and predictable, interfaces easy to understand and which provides a sense of continuity taking into account that they have the same ‘look and feel’ across devices.

However there are always small details that may be improved as for e.g. the web content interfaces when accessed from iTV and from mobile device.

RQ1*: Which model interface design and functionalities are adequate in order to:* ***c)*** *Create personalized web contents appropriate to give sequence and continuity to informal learning opportunities created by the visualization of the* *video (are they able to contextualize viewers in relation to what they first saw and provide further coherent content)?*

The contextualization was one of the main concerns and in all the interfaces this design had a fundamental role. Several prototypes designed with different contextualization options were tested (when entering each web content topic tab: to have an excerpt of the video from the exact moment of the topic selection; to have that excerpt from a few seconds before the topic selection; to have an image instead of a video; to have both an image and a video; to have the video excerpt playing and to have the video paused). Some possibilities were even tested more than once in high fidelity prototypes. The goal was to find design options that best matched the viewers' needs and desires, and the results were as follows:

In terms of **contextualization**, when entering each web content topic tab: to have an excerpt of the video from a few seconds before the topic selection; to have a video instead of an image in order to contextualize or to have both; to have the video excerpt playing with a pause option available. Through the web content, be able to access the video that was used to generate it, by simply clicking an icon with a video camera, for familiarity, taking advantage on previous viewer experience. Similarly, through a video, being able to access the generated web contents if there is any. In viewers opinion the contextualization totally succeeded.

In what refers to **personalization**: it was evaluated as positive being the preferred options in terms of web content topics presentation, the chosen order (nevertheless, viewers also recognized the importance of having the two other options available: alphabetical and content dependent topics order). Also appreciated were: 'My Input' tab; the flexibility that was provided to the manipulation of each web content piece of information and the possibility to export different types of contents and files to the web content, from all the devices, at any time, especially if from the mobile devices.

From the proposed three levels of information in relation to the topics choice, the great majority preferred levels 1 and 2 (being 1 the favorite). In information levels 2 and 3 they preferred the embedded rather than overlay design.

In terms of **continuity**: as to the extra information presented on the web content, it was also evaluated very positively in quality and depth considering that viewers found the extra information provided, on each topic, complementary to the video and not a repetition. Viewers also stated that, for e.g., the presented video excerpt from the original video, the used information and the graphical elements used through all UIs helped in creating a sense of continuity.

RQ2*: Is there a real advantage in connecting these devices in order to generate additional web content information to a video?*

Absolutely! In general terms, in all generations, viewers were very enthusiastic about the idea of having the possibility to ask for extra information about what they were watching. In fact, they all agreed that, at least once, they already conducted web search after, sometimes during, a video watching in order to know more about it and enjoyed having this as an integrated feature. Viewers really appreciated to have the application available from any device, at any time and any place, thus providing them with extra flexibility and being adequate to different cognitive modes and contexts of use. They were also aware that each device, beyond contributing to mobility, is able to contribute by offering different functionalities and, due to its specific characteristics, complementing the others. Viewers highly appreciated the possibility to have the web content stored for view when possible and needed, and to be able to share it with friends. In more specific terms, from the proposed three levels of information in relation to the topics choice, the great majority especially preferred levels 1 and 2 (being 1 the favorite). Nevertheless, when used, level 2 information was highly appreciated due to the possibility to see a brief summary of the topic immediately. Much appreciated was the possibility to synchronize devices and use them in a ‘second screen’ fashion, namely, watching video on TV while watching already generated web contents through PC. Also highly appreciated the possibility to engage in content-based and location-based search from the mobile devices. The search functionality which allows to search videos based on different criteria was also considered important as well as the amount and type of information that is presented when a video is found.

As to devices, in what refers to the create functionality, TV and PC were the preferred choices in order to generate the additional web content, being TV considered the most visually pleasant interface and the PC interface the most well designed. For viewers, well designed interface was associated with the experience of use, with usability. They considered the PC interface the most well designed because it was the easiest to use, to access and navigate. Nevertheless, the mobile interface was considered the easiest to learn but the least visually pleasant mainly due to limitations related to the device characteristics, in this case the small screen size, than with the designed interface. This discomfort was mainly felt when they changed from larger devices, TV and PC, to the mobile phone. When the mobile phone was the first device being used, they did not feel the same, which is understandable.

RQ3*: What are the preferred interface designs for the relevant cognitive modes and needs in each scenario? Along the several options and functionalities, which interfaces work best to support the different cognitive modes (experiential and reflective) and levels of attention?*

We are comfortable saying that we have achieved very good interfaces, adequate to different cognitive modes and needs in each scenario. In fact the evaluation results were better than expected.

When in a more passive experiential cognitive mode, viewers preferred: information level 1 (instead of 2 and 3) and embedded rather than overlay when levels 2 and 3 are used; to have the video playing (by default) everywhere: when choosing a topic in information levels 2 and 3 (both in embedded and overlaid design), when searching for a web content and when accessing a web content. Nevertheless, they all agreed that a pause option should be made available in order to provide them with extra control and flexibility when engaging in a more reflective cognitive mode.

When in a reflective cognitive mode, viewers preferred: information levels 1 and 2; embedded rather than overlay when levels 2 and 3 are used; keep the videos playing while reading the topic explanation but with the possibility to stop it when needed; watch the generated web content and editing it; synchronize devices in order to used them in ‘second screen’ mode. When waiting for something (for e.g. at the end of the bar queue) they tend to use that time in order to engage in content-based and location-based search and personalize their web contents through: the addition of other files, changing blocks of information from one tab to the other; rearrange the MyInput tab, define privacy options, etc. Nevertheless, the mobile interface was the most difficult to use to accomplish these web content personalization tasks due to the amount of information and the small size of the screen. When referring to the mobile device, the location-based search was one of the most thrilling features for viewers, immediately followed by the content-based search.

In both cognitive modes: viewers are becoming more comfortable using the color keys shortcuts from the TV remote. As to the generated web content, they prefer the topics ordered by the order of appearance and selection in the program instead of alphabetically. Few viewers found the merge web contents functionality interesting which is understandable considering that they did not create several web contents to the same video, thus being hard to understand this functionality real usefulness. Similarly few viewers found the automatic sending e-mail functionality, responsible for keeping web content receivers up to date, interesting. On the contrary, the majority of viewers found the feature that automatically generates web contents very interesting and useful. This functionality, already designed in the first generation prototypes allowed to generate the web content automatically if, by chance, in the middle of the TV program, the viewer changed channel or turned of the TV without exiting the application. This functionality evolved through generations and, now it is also triggered from the other devices. In fact, if by chance the viewer is generating a web content from the mobile phone and receives a call, or if the viewer is generating a web content from the PC and receives an automatic restart message, the application generates the web content automatically with the chosen topics until that moment.

RQ4*: What other functionalities would viewers like to have in this kind of crossmedia environment, capable to generate extra web content to video?*

In the first generation, only three subjects provided individual feedback on this aspect. Two suggested the provision of synchronous communication (chats) and one suggested the possibility to generate web contents from the PC, considering that he is used to watching movies and TV from there.

In the second generation, only one viewer specifically suggested that the application could work integrated with the Facebook but when asked about other possibilities in terms of web content contextualization, 33% of viewers suggested the use of video and images simultaneously in order to contextualize faster considering that the excerpts of video used started a few seconds before the moment of the topic choice (more than a specific functionality, this was an alternative option to an existent functionality).

In the third generation, five users suggested the use of an instant messaging functionality inside the eiTV application. Two viewers (both from the group with more technological literacy) suggested the use of an automatic annotation method instead of inserting metadata manually which is aligned with our rationale of providing both for automation and flexibility. One viewer with lower technological literacy suggested the possibility to use apps inside the iTV application in order to allow viewers to be aware on friends birthday (like it happens on Facebook), showing interest in the social aspect, based on previous user experience.

Being a new type of application, it is understandable that most viewers did not have clear ideas about future functionalities, being our job to devise some (for e.g. synchronize devices, search by GPS coordinates). Thus being, and in order to launch some discussion and dynamics both in first and second generations, during the focus groups evaluation, some functionalities, features and options were launched for discussion in order to understand their acceptability. The most 'voted' were the ones being implemented in each generation with very good results.

RQ5*: Are the different devices (with different characteristics and thus different possibilities) as part of an ecosystem (in order to have an identical model and functionalities available across devices) easily adopted by viewers?*

Yes, we have reasons to believe that it will be a success. During the evaluation sessions, viewers were very thrilled with the third generation prototype and about being able to synchronize devices, use them in a 'second screen’ mode and being able to use content-based and location-based search in order to personalize their web contents or simply watch related images and videos. Some information from the third generation evaluation, the one referring to the prototype with a higher level of complexity, due to the number of functionalities, features and options implemented, may be considered good indicators. In fact, the raising in the cognitive load along generations is low if considering the higher complexity of the prototypes in terms of new functionality. Other good indicators were, for e.g., the number of viewers that would like to have the eiTV application (100%) and the number of viewers that would recommend it to friends (100%).

Some viewers, the more technological literate, still send me e-mails asking when the final service will be delivered to the public. All of them were very enthusiastic with the idea of using the application from several devices, the majority due to the mobility they gain.

RQ6*: Were the proposed frameworks, for crossmedia and iTV, adequate and efficient?*

Considering that the design and use of the eiTV application and the iTV interfaces were conducted through generations following the directions identified in the crossmedia conceptual framework and iTV framework, respectively, and that the achieved results were good, we have reasons to believe that we were capable to identify critical points and possible solutions to the design of crossmedia applications and iTV interfaces.

Conclusion: The results achieved were very good as presented in this section and allowed to make evolutions along the three generations identifying usability problems and find out tendencies for most appreciated aspects. Nevertheless, due to the sample size the results could not be generalized but are an excellent indicator.

5.3. Future Work

In spite of the long run and the good results achieved, there is a lot to research on video-based crossmedia. Many challenges can be addressed, as for instance:

Extend the application to include tablets as a fourth device. This may seam a simple task but tablets are recent devices and have specific characteristics that should be addressed in the design of the interfaces in this context. In spite a penetration rate of 1,5% (Cardoso et al., 2012) it is quickly spreading, at least, within the academic community. In terms of challenges, for e.g. design to the new contexts that this device brings in order to accommodate different cognition modes. As to benefits, these devices bring the mobile advantages from mobile phones without the limitation of the small screen size, being in our opinion a promising device and a research path to follow;

Adopt automatic content classification (and metadata) gathering. Several technological options are already available and could be integrated in our application, as previewed in our prototypes, complemented with access to services like youtube or flickr to search for information often classified by keywords provided by users. This would certainly increase the power and flexibility of this functionality if supporting different media (especially images, video, audio, etc.);

Implement the service (the application) to other program genres as documentaries and news which presents us with different challenges due to their different dynamics. Different program dynamics will require different interaction modalities and interfaces in order to accommodate changes in cognition modes and contexts of use. However, this research will bring the opportunity to spread the service to different program genres;

Explore the possibility of using communication tools within the application, as suggested by some students, namely, instant messaging in order to allow them to communicate with their friends while watching a video. The important role of socialization while watching TV was already demonstrated and may be included in this type of application in order to explore extra possibilities in terms of socialization and collaboration. Also important to explore and evaluate the impact and research of the variables associated to the creation of group profiles (to be available from iTV). TV still is a social activity commonly shared within a group of people in the same room. Thus being, each member has its own needs, interests and cognitive modes while watching the same video. In order to accommodate this group viewing situations some new challenges arise and are interesting to explore as, for e.g., how to simultaneously support multiple viewers with different cognition modes and needs;

Research the advantages associated to the migration of the application to the cloud, in order to provide more flexibility in terms of contents that may be shared, as for instance large documents;

The possibility to include virtual reality HD, 3D and panoramic TV in the future iTV is gaining strength. That will allow a considerable number of changes in the way people act and behave when in the presence of TV. With this type of technology, TV will be used to engage in true immersive experiences with viewers participating in games with their friends (at distance), travelling around the world without living home, and so on. However, these technological advances will have an impact in conceptual questions related with cognition modes, contextualization, flexibility, etc., considering that complete new contexts with different dynamics of interaction are being born. This raises new challenges in terms of research that should be addressed as, for e.g., the study of the mentioned conceptual questions associated with this new type of dynamic and contexts of use.

Research the impact of the inclusion of different modalities like speech input that could be used in specific situations (as for e.g. while waiting for the bus, with one hand holding an umbrella and the other hand holding the mobile, the viewer may want to watch a video and select topics which could be achieved by simply repeating the word instead of having to touch the screen). This functionality may be implemented in all devices (as an alternative to other input forms) thus providing viewers with more flexibility, personalization and adapts to changes in cognition modes and different context of use. The advantage of multiple input modalities is increased usability and flexibility: the weaknesses of one modality may be offset by the strengths of another.

Explore new modalities of content-based search as for instance sound, movement, smell and taste. In fact mobile devices are commonly used and are increasingly incorporating sensors and actuators which provide them potential to support more powerful and immersive video user experiences. A new richer functionality could be, for e.g., content-based search in the following scenarios: with movement sensors, viewers being able to capture some dance steps (movement) and, based on that, search for videos where that type of dance steps are being used giving access to additional info to help in learn how to dance this style of dance; through GPS, enter a movie shot in the same location scene I am now (Noronha *et al*., 2012); through smell sensors viewers could capture a specific smell and use it to search videos with that same smell on it or a movie, or an advertisement from where I could by my next gift; and the same happening for taste, allowing to search for recipes or taste the food my mother cooked in the video she sent me (Cheok, 2013); or I could enter a movie scene playing the same music that I am listening to in the place I am right now, that I may choose to watch in a wide TV screen while getting second screen about the music, the movies, and a whole new world of possibilities where I can participate and get immersed into. In order to technically implement these scenarios of use, sensors and to have the information cataloged in accordance is needed.

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Annexes

Annex A. Questionnaire to Choose the Program Genre

This questionnaire aims to collect information about your TV programs preferences. Thank you in advance for your participation!

Note: every collected data will be used just for what was mentioned and will be processed with confidentiality and anonymity. The average time to fill the questionnaire is between 3 to 5 minutes.

A. Personal Data

1. Age: _____
2. Sex: ☐ Feminine ☐ Masculine
3. Your situation in terms of studies/work:

   ☐ Student ☐ Worker ☐Student and Worker

   Working place: ______________________________

   Working function: ____________________________

   Student of:

   ☐ ISMD ☐ MKTD ☐ HRMD ☐ Not Student

B. Television habits

1. Please order the types (genres) of programs that you usually watch (use 1 to the program that you see most; use 2 to the second program that you see most; etc). Please don't give a number to those programs that you never see.

   ☐ News

   ☐ Reality shows

   ☐ Quizzes

   ☐ Soap Operas

   ☐ Sportive

   ☐ Films

   ☐ Documentaries

   ☐ Music programs

2. In terms of documentary your favorite subject is (**choose only one option**):

- ☐ Animal life
- ☐ Natural phenomena
- ☐ Paranormal phenomena
- ☐ Space
- ☐ Physics
- ☐ Human body
- ☐ Other: ___________________________

3. In terms of film category your favorite one is (**choose only one option**):

- ☐ Specific Series (Dr House, CSI, Doctor in Alabama, Bones, etc)
- ☐ Action
- ☐ police
- ☐ Horror
- ☐ Comedy
- ☐ Romance
- ☐ Science Fiction
- ☐ Drama
- ☐ Other: ___________________________

3.1. In terms of 'Specific Series' which are your 2 favorite ones? (By order of preference)

Favorite: ___________________

Second favorite: ___________________

Many thanks for you collaboration!

Annex B. Questionnaire to Characterize Viewers

This questionnaire aims to collect information about your demographic profile, technological literacy and previous experience with crossmedia. Thank you in advance for your participation!

Note: every collected data will be used just for what was mentioned and will be processed with confidentiality and anonymity. The average time to fill the questionnaire is between 3 to 5 minutes.

A. Personal Data

1. Age: _____

2. Sex: ☐ Feminine ☐ Masculine

3. Your situation in terms of studies/work:

   ☐ Student ☐ Worker ☐ Student and Worker

   Working place: ______________________________

   Working function: ____________________________

   Student of:

   ☐ ISMD ☐ MKTD ☐ HRMD ☐ Not Student

4. Tell us about you literacy level:

Concluded	On going	
☐	☐	Basic
☐	☐	High School
☐	☐	Bachelor in: ________________________________
☐	☐	Master in: ________________________________

Name of your last school: ____

5. Contact Information:

   Name: _________________________

   E-mail: ________________________

   Mobile: ________________________

B. Television Habits

1. In average how many hours of TV do you watch each day?

☐ I never watch ☐ Less than 1 hour

☐ Between 1-3 hours ☐ More than 3 hours

(if you answered **'I never watch'** go to **group C**.)

2. Tell us **HOW** do you usually use TV in each of the following circumstances:

	Don't use it this way	Less than 1h/day	From 1 to 3 h/day	More than 3 h/day
As main attention focus (while watching a film, documentary, etc)	☐	☐	☐	☐
As 'companionship' while studying, cleaning, talking with friends, etc	☐	☐	☐	☐
As 'companionship' while using the computer	☐	☐	☐	☐
As 'companionship' while using the mobile phone	☐	☐	☐	☐
As 'companionship' while using the tablet	☐	☐	☐	☐

3. The majority of the time that you watch TV you do it:

☐ Alone ☐ With Friends ☐ With Family

4. Please order the types (genres) of programs that you usually watch (use 1 to the program that you see most; use 2 to the second program that you see most; etc). Please don't give a number to those programs that you never see.

____ News
____ Reality shows
____ Quizzes
____ Soap Operas
____ Sportive
____ Films
____ Series (ex: CSI, Dr. House, Bones, etc). Your preferred one is: ___________
____ Documentaries
____ Music programs

5.Has already happened to you while watching a program:

	Never	Few Times	Sometimes	Many Times	Always
Want to know more about one (or several) topics being discussed (ex: while watching a sportive documentary to think that they haven't speak enough about a certain player)?	☐	☐	☐	☐	☐
Search pen and paper to annotate something that you are watching/hearing in the program (ex: someone name, an e-mail, a telephone number, a specific topic, an institutions name, etc)?	☐	☐	☐	☐	☐
Use the teletext?	☐	☐	☐	☐	☐
Use interactive television services (ex. MEO, ZON, Cabovisão, etc)?	☐	☐	☐	☐	☐

6. Which TV operator do you have (Zon, MEO, Cabovisão, etc)?

____

____

7. Which of your TV operator Interactive Functionalityes do you use?

____

____

C. Profile/Technological literacy

1. Do you have your own **computer**?

☐ No ☐ Yes

1.1. If the answer was 'Yes' tell us:

☐ **With** Internet connection ☐ **Without** Internet connection

1.2. Tell us what type of computer do you have:

☐ Laptop ☐ Desktop

2. Choose the more adequate option to your case:

	I don't use	Less than 1 time/ week	1 to 7 times/ week	Several times/day
In average, how often do you use the computer?	☐	☐	☐	☐
In average, how often do you use Internet?	☐	☐	☐	☐

Note: If you dont use the Internet go to question 4.

3. How often do you use each one of the following Internet functionalities through the **computer**?

	I don't use	Less than 1 time/ week	1 to 7 times/ week	Several times/ day
e-mail	☐	☐	☐	☐
Instant messaging (ex: MSN)	☐	☐	☐	☐
Social networks (ex: facebook; hi5, etc)	☐	☐	☐	☐
Video-conference	☐	☐	☐	☐
Watch videos of interest	☐	☐	☐	☐
Watch TV	☐	☐	☐	☐
Discussion forums	☐	☐	☐	☐
Search specific information through the Web	☐	☐	☐	☐
Visit usual websites	☐	☐	☐	☐
Moodle	☐	☐	☐	☐
Twitter	☐	☐	☐	☐
Podcasts	☐	☐	☐	☐
Blogs	☐	☐	☐	☐
Skype	☐	☐	☐	☐
Other	☐	☐	☐	☐

4. Do you have, or already had, your own **mobile phone**?

☐ No ☐ Yes

4.1. If the answer was 'Yes' tell us if your mobile phone:

☐ **Have** Internet connection ☐ **Don't have** Internet connection

4.2. Tell us which type of mobile is it:

☐ Smartphone ☐ Common mobile phone

4.3. If in 4.2. your choice was 'smartphone' please tell us the brand, model and operating system:

____

5. How often do you use(d) each of the following functionalities through your mobile phone?

	I don't use	Less than 1 time/ week	1 to 7 times/ week	Several times/day
Make Phone calls	☐	☐	☐	☐
Send SMS	☐	☐	☐	☐
Send MMS	☐	☐	☐	☐
Use e-mail	☐	☐	☐	☐
Search information on the Web	☐	☐	☐	☐
Video-conference	☐	☐	☐	☐
Listen music	☐	☐	☐	☐
Take pictures	☐	☐	☐	☐
Produce videos	☐	☐	☐	☐
Watch videos of interest	☐	☐	☐	☐
Watch TV	☐	☐	☐	☐
Interact with social networks (ex: facebook)	☐	☐	☐	☐
Use GPS	☐	☐	☐	☐
Play games	☐	☐	☐	☐

6. If you don't use interactive television the questionnaire ends here. In case of using interactive television tell us how often do you use it to access each of the following functionalities:

	I don't use	Less than 1 time/ week	1 to 7 times/ week	Several times/ day
VOD (*vídeo on demand*)	☐	☐	☐	☐
Vote on TV programs	☐	☐	☐	☐
EPG (*electronic program guides*)	☐	☐	☐	☐
Plan program recording	☐	☐	☐	☐
Use Widgets (games, weather, news, etc)	☐	☐	☐	☐
See films with 3D	☐	☐	☐	☐
Listening radio	☐	☐	☐	☐
Send messages	☐	☐	☐	☐
Use e-mail	☐	☐	☐	☐
Search information on the Web	☐	☐	☐	☐

Other functionalities. Which ones? ____

____

7.Imagine a crossmedia application which integrates interactive television, computer and mobile phone. From any of these devices at your choice, and while watching a video, you may choose the most interesting topics. Based on the selected topics the application generates a website with additional information about the chosen topics. The website remains stored in order to be accessible when needed and from any of the mentioned devices and may be edited as you which. How do you classify your level of interest in having this application?

☐ No Interest	☐ Little Interest	☐ Average Interest	☐ Much Interest	☐ All the Interest

Many thanks for you collaboration!

Annex C. Design Guidelines for iTV

Text Guidelines

• The text pitch used must be 18 minimum in order to be visible from 3 to 5 meters away, which is the distance between the viewer and the TV set. Usually, the recommended pitch is 20 for general text and 18 for the observation section(s) or subsection(s). As to the font style, Arial, Helvetica, and Verdana are recommended. Other font styles may be used, but only if embedded as images. However, this solution needs to be carefully considered since the result will be a much heavier file.

• Small-pitch text embedded in images should be avoided since the browser frequently resizes these images automatically.

• The text paragraphs must be short in order to not occupy several screens and thus impose the use of scrolling, which is a feature that is hard to handle in iTV.

Graphics and Background Guidelines

• Rigorous graphics should be avoided since there is always a little toning down (Thin lines may result in some scintillation).

• Animated graphics, that is to say, graphics with lots of movements, should be avoided.

• The usage of image maps should be avoided since they are complex to handle on a TV set.

• The use of very small frames must be avoided since this may result in many differences in the Web page as seen through the PC browser and when seen through the set-top-box browser.

• It is preferable to use normal graphic buttons with simple words than very graphical buttons full of colours.

• The TV object (video file embedded in the TV site) should be as large as possible, but the equilibrium between that object and the remaining information (normally textual information) must obviously be kept.

• When designing a TV site, it is necessary to take into consideration a status bar with a height of 40 pixels. A margin of 16 pixels is recommended for the perimeter of the screen.

• The background, instead of being an image, should be developed directly in the programming code in order to have less weight. However, if an image needs to be used, it should be simple so that it may be replicated all around the screen without becoming too heavy. Watermarks may also be used since the image only contains one colour.

• Dark colours should be used as backgrounds. Highly saturated colours such as white should not be used.

Interactivity Guidelines

• Interactivity may be available in two options: The TV object may be integrated in the Web page, or the contents may be displayed over the television signal.

• It is essential to bear in mind that the program broadcast is of greatest importance. The rest is secondary and is used to improve the viewer's television experience.

• The interactive content is supposed to improve the program broadcast without disturbing the viewer's entertainment experience.

• The service must be pleasing to the viewer; otherwise, s/he will change the channel.

• The interface must be easy to understand and allow for easy interaction. A bad design typically forces the viewer to click a large number of times in order to reach important information. It is important to keep in mind that a large number of clicks does not necessarily mean a very interactive service. Similarly, easy of interaction does not mean less interaction.

Other Guidelines

• The dimensions of the TV object must maintain the format 4:3 in order to not distort the television image.

• Each screen should not take more than 3 to 5 seconds to download. However, the ideal time is around 2 seconds, which is the time it normally takes to change the TV channel.

• Vertical scroll, although possible, should be avoided since it is not practical to navigate via a remote control (However, vertical scroll is used in almost every Web site).

• It is important to remember that not all viewers are experienced in the use of Internet scrolling and navigation.

• There is a significant difference between the way we capture the iTV viewer's attention and the way we capture the Internet user's attention. The iTV viewers are used to be entertained, so the challenge will have to be very high in order to capture their attention. The quality of the service will also have to be high in order to keep their attention.

Annex D. Design Guidelines for Mobile

A) Haywood & Reynolds (2008) set of guidelines to design touchscreen solutions for mobile handsets:

Screen size matters

• When it comes to touchscreens, screen clarity and size matters - large good quality screens are essential to provide space for key elements.
• As larger screens may foster concerns over vulnerability, the handset's design needs to support notions of robustness and quash any concerns over screen fragility.

Touchscreen responsiveness

• Aim towards minimising touch response lag. Delays will frustrate and confuse users, encouraging repeated selection of target elements. Optimising responsiveness will dissuade users from pounding the keys and/or using their finger, nail or pen, like a stylus.
• To minimise keying errors as much as possible, ensure that sensitivity and screen alignment (calibration) are optimised.
• Maximise sensitivity levels, uniformly, across all areas of the screen. Particularly where a scroll bar draws the users' focus, sensitivity at the perimeter needs to be optimised.
• Consider the option of a universal stylus to minimise concerns associated with large fingers, long fingernails, or dexterity and accessibility issues, more generally.
• The tactile experience offered by a conventional keypad, both in terms of the spatial arrangement of keys and the feedback upon selection, offers a positive effect on efficiency and error rates as well as user satisfaction. Therefore:
Consider options to support a more tactile user experience – e.g. vibrational sensations in response to user selections. If this is supplied, users must be given the option to turn this feature off.

Navigation & efficiency of use

• If users have problem with the most basic functionality they will feel negative about the product: Support key functions such as answering or ending a call, instant messaging, listening to music, viewing messages, accessing the internet, etc. and minimise steps to access or perform such functions, by keeping access points at a high level.
• Allow clear and direct navigation to return Home and the Main Menu. This is especially important where the device doesn't present a physical button dedicated to this.
• Ensure consistency throughout the interface, as this reassures users and allows ease of navigation.
• If possible, provide a search option in addition to the option to scroll through a contacts list.
• Support flexibility by allowing users to create a shortcuts menu, based on their priorities.
• Struggling to perform functions will frustrate users. Therefore, if feasible, provide a Help system on the phone that is easy to find and use.

The virtual keypad

If devices exclusively rely on a virtual keypad, the aim should be to mirror levels of speed and accuracy offered by traditional handsets as far as feasible.

• Without an explicitly presented physical keypad, clear access to the virtual keyboard is vitally important. Users must not be left wondering how to enter text using the touchscreen.
• In terms of its design, consider presenting a QWERTY keyboard instead a multi-tap configuration where characters are shared on individual keys: Without the familiar tactile cues of a conventional keypad, a QWERTY layout will be easier to use than a multi-tap keypad – with the latter, lag and precision issues may come to the fore.
• Ensure that users can change between different text input modes with ease: Options to enable and disable predictive text and switch between letter, number or symbol inputs, must be clearly presented and quick to use.
• Ensure the selectable area (icon/button) is larger than the target or of an acceptable size: Users need to feel confident that selecting a button is going to perform the task. Remember people will want to reach for a stylus if things go wrong or if they don't feel confident that their selection will be accurate.
• As well as being sized to accommodate finger-input, users need to perceive keys to be adequately sized for accurate selection: Explore ways to maximise the perceived size of the keys on the virtual keyboard. For example, minimise concerns about the size of fingers relative to the keys, through a good visual design, where a good delineation of keypad elements is presented.

Icon design
• Make use of familiar icons so users can associate with them.
• Where icons are relatively abstract, users will become frustrated if they continually struggle to locate target features. For example, without a physical key, ensure that the means to end a call is highly visible.
• Ensure visibility of icons if using abstract designs or faded out/graduated target areas.
• While preserving a non-cluttered display, consider supplementing the icons with labelling or other textual cues. A cluttered display will impede the user's selection.
• Provide the option for users to personalise the phone - colour schemes, design skins, etc.

Locking mechanism
The ability to lock touchscreen handsets is typically cited as a concern by users.
• Quash concerns about accidental activation, by providing an explicit means to 'lock' touchscreen devices: To support perceptions of robustness and minimise concerns, it is suggested that a metal slide key with definite tactile feedback, is considered.
• Ensure that the locking mechanism is intuitive, and that advice on this is given suitable priority in the user manual, so that users do not learn the hard way how to lock the device.
• Provide an automatic lock facility (after a period of inoperability).
• As with more traditional mobile phones, allow the lock to be overridden when there are incoming communications.

Battery life
Battery life is becoming an increasing concern of consumers, as devices accumulate more and more features.
• Work towards maximizing battery life and encourage use by managing associated user expectations in any accompanying documentation.

B) Keinänen (2011) 60 UX guidelines for designing high-performance mobile user experiences.

Page layout

1. Prefer portrait websites over landcape websites.
2. Important elements need to be visible when the page is only a couple of inches in size. Make navigation elements visible even when the page thumbnail is viewed, e.g. using noticeable colouring and shapes.
3. All relevant content or cues to content should always show in the upper part of the page, preferably in the upper left corner.
4. Content layout and element sizes should not vary too much between different pages on a website. For mobile accessibility, it is recommended that the website layout is consistent.
5. Align the content vertically. Consider using a column-based layout for easy mobile browsing. This way users only need to scroll vertically when reading the content.
6. Do not use large banners if you have many mobile Web customers. If banners are needed, position them on top of the header, not between the header and content.
7. With a reasonable zoom level, users should be able to view text and images without scrolling sideways.
8. For a pleasant use of smart zoom, all elements should be comprehensible whentted to a 3.5" screen.
9. In text, do not exceed a row width of 50-60 characters. Do not use elements of the page's full width for relevant content, especially for text. E.g. for advertisements the full width is acceptable.
10. Let the browser adjust the text column width, i.e. use a liquid layout for text elements. However, define a maximum width at around 80 characters per line for good desktop legibility.

Navigation and links

11. Prefer vertical navigation link lists to horizontal ones from the 2nd level on.
12. Make all link lists as loose as reasonable.
13. Invest in link affordances. Make all links look like links so that users can avoid swiping on them to avoid unwanted clicking.
14. Make all buttons big enough for fingertips even if the text or icon on the button is small. When viewed on a touch screen phone, the button is recommended to be approximately 1x1 cm in size, when the user has zoomed in to the related column width.
15. If using dropdown menus as navigational elements, ensure they work as intended on devices with poor JavaScript support. Consider providing an alternative solution for incapable devices.
16. If using mouseover dropdowns, ensure that there are other ways for navigating on the site. In all navigation, prefer on-click functionalities to hover functionalities.
17. Ensure that contact information can be found either on the front page or on the second level of navigation on a `Contact' page or similar. All text that the users might want to select or copy, such as phone numbers, street addresses, product details, news etc. should be implemented as plain text.
18. Pay special attention to link texts' information scent if your site is often used by mobile users.
19. If the information on a website is location-specific and you have sites for many locations, allow the user to easily access other locations' contact information e.g. via the header or a contact page.
20. If you have a mobile site, show the link to the mobile site at least in the full site header. Also, provide a clear link back to the full site on the mobile site.

Websites with heavy content

21. Avoid building websites with heavy content if you have a steady number of mobile users. If the content cannot be reduced, provide a lighter version for slow network connections and for mobile use.
22. Show the page at once after the whole content is downloaded. Do not leave the styling as the last received package. Showing text-based link lists when it is not possible to click on them is confusing for users with a slow network connection.
23. When using anchored links on pages with changing content, show the correct part of the page already before the content starts showing.

Incompatibilities.

24. If you decide to use Web technologies with known incompatibilities, always test the solutions with several browsers and devices. E.g. test how the site works with non-Flash browsers and test your JavaScript effects to make sure they work as intended.
25. If a part of your website cannot be used with some devices, tell it to the user. Define the devices which do not support the incompatible feature. Do not e.g. tell that `There are some parts on this page which do not show in some devices'. Instead, provide useful information for these users.
26. If you decide to use Flash, always provide an alternative way for viewing the content.
27. Make sure that the missing Flash elements do not dislocate the page layout or functionality.
28. Flash content always adds to the page download time - use it sparingly.
29. Do not allow users to download incompatible software, i.e. disable the downloading for wrong devices.

Web forms and other input

30. It is recommended to make the form fields, spaces, buttons, and boxes as big as reasonable for easy selecting.
31. Always show the field titles as static labels next to or on top of the fields.
32. It is not recommended to use fields that incorporate both a widget and the keyboard, e.g. a combination of text input and calendar widget is dificult on touch-only devices.
33. Provide forms on a single page whenever suitable. Do not make the users do unnecessary back and forward clicking.
34. Consider implementing suitable checkbox and radio button selections with menus. For touch screen use, menus are a lot easier to notice and use. Always allow the device list functionality to show the menu content. E.g. instead a checkbox a yes/no menu can be applied, and instead a radio button a menu of choices can be applied. This applies especially for mobile-optimized websites directed to touch screen device users.
35. When using menus, ensure all possible options are shown in the list.
36. For date selections, use a calendar widget.
37. If both a start/leave and an end/return time are selected on a form, the fields should be linked, i.e. the other should change automatically according to the one selected. E.g. end/return time can be set at one hour or one day from the start/leave time, depending on the use case.
38. Use autofill, suggestion listing, and browser form history in text boxes whenever applicable.
39. Provide a clear button next to text boxes for easy written text removal.
40. If the user's current location is needed, use the phone's GPS coordinates for filling in the related fields.
41. Always put a confirmation button at the end of the form so that the user can safely edit the content of each field before submitting anything.

Maps and lists

42. Make sure that touch screen users can use your map. Pinch and sweep are the recommended ways for zooming and panning on touch screen, instead of buttons. However, for a map compatible with both touch and non-touch screens, both control types should be implemented.
43. If you use elements with scrollable lists, make the functionality visible. However, allowing the use of the device's own list functionality is always recommended instead of nested lists.

Device detection

44. If you have a separate mobile website, redirecting mobile users automatically is always recommended.
45. If you do not want to redirect your user, asking the user whether he wants to access the full or the mobile site is also a recommended option.
46. If you decide not to use redirecting at all, ensure that a link to the mobile site can be easilly found in the full page header when viewed on mobile devices.
47. It is recommended to make an effort to show the mobile site in search engine results when the search engine is used with a mobile device.
48. Test that devices are detected correctly, and offer touch compatible content for all touch devices, whether in form of an enhanced full site or a touch optimized mobile site.

Separate mobile websites

49. For most websites and Web services, developing a separate mobile website is not justifiable. Ensuring compatibility with mobile devices, especially with touch devices, is recommended.
50. Developing a single mobile site accessible by touch devices as well as non-touch devices can be a reasonable solution for a rather simple Web service.
51. If applications for difeerent high-end devices are available and they have optimized functionalities, users do not need a separate mobile site in the browser. In these cases, a mobile site for the low-end devices can be built if mobile users are detected.
52. If the budget only allows for either an application for difeerent devices, or a mobile-optimized website, develop the one you can make better. Users do not care whether the service is used via a browser or an application. Ensure that your mobile users are aware of the developed mobile service e.g. by announcing it on the full website.

Mobile website content

53. If you decide to build a separate mobile website, do not build it blindfolded. Spending resources on developing a mobile site without studying the mobile users, e.g. by site analytics, is not worth it. Users very probably return to the full site if they cannot find the content and functionalities they need in the mobile context.
54. Find out the things users might want to check on your website when browsing on a mobile device. Use site analytics to determine how much your site is accessed with mobile devices, and what the contents and functionalities mobile users view and use are.
55. If some content can only be found on the full site, tell it to the mobile user and offer a link to full site with a clear indication that it leads to the full site.
56. Name all links to the full site in a clear way so that the user does not leave the mobile site unintentionally.
57. Switching between the full and the mobile site in the navigation is irritating and confusing. Stick to the mobile interface by providing links only between mobile pages.
58. Ensure all the information on the mobile site is in line with the full site.
59. Use a header that tells the site name and provides a links to the site's full version.

60. Enabling as many of the address versions (m.site.com, site.com/mobile, site.mobi, mobile.site.com etc.) as possible is recommended for easy mobile access.

C) Weevers (2011) 7 UX guidelines for designing high-performance mobile user experiences:

1. Define UI Brand Signatures

Each user interaction with an app should reflect the story of the brand and should increase recognition, loyalty and satisfaction. Identifying which elements contribute most to the brand's identity is essential. Examples are features, visuals, wording, fonts and animations. Our design teams work on many different products on different product teams. This could easily lead to several design and implementation variations of similar UI elements. Defining the core building blocks encourages reuse and discourages reinvention and, therefore, optimizes the design and implementation of a set of components.

One approach is to define the UI elements that form the core building blocks of the user interface and, together, to create the interface's unique character. In the concept phase, identify those elements that do the following:

- Differentiate the app (for example, the photo-viewing feature in the Path app);
- Represent key functions (for example, a check-out feature for a store);
- Set the pattern of the design language.

2. Focus the Portfolio of Products

Whether a company wants to launch a product quickly, or develop a product portfolio (i.e. multiple products on one platform, the same product on multiple platforms, or both), or if facing limited time and resources, hard choices have to be made. Design and optimization efforts should be targeted at those products in the portfolio that matter most. A design priority matrix helps us understand where design efforts will pay off the most.

Focusing design efforts helps to optimize performance in the most rewarding areas. For example, if most of your anticipated customers are using Android phones, and competitors are also targeting them, dedicating more design effort to creating an elegant and fast Android app would be more valuable than dividing your efforts equally across all platforms.

3. Identify the Core User Stories

Our teams have faced several project kick-offs in which the initial list of requested features was lengthy, unfocused and impossible to build within the requested timeline. When dreaming up what a product should do, companies often lose sight of the fact that customers look for solutions that help them with very particular needs.

For example, one main shopping goal (besides socializing, inspiration, etc.) is to find and purchase a product. Whether in a small city, on Oxford Street in London or on the Internet, it's about finding and buying what you're looking for. The experience could be enriched to make shopping more fun, but the core goal-finding and purchasing-should never be lost. The same applies to the design of a shopping app (whether for games, music, vouchers). The user needs to be able to find and purchase quickly, regardless of whatever other functions that enrich the overall experience.

4. Optimize UI Flows and Elements

Users don't like to wait. (Google puts "Every millisecond counts" as the second principle of its user experience.) Optimizing individual screens, flows and UI elements will reduce waiting times and keep users from thinking that they're wasting their time.

4.1. Speed up perceived performance

The designer cannot control performance all of the time. The network might be slow; the device might be running other tasks in the background; certain operations might require a lot of calculation. If the user at least perceives that they are not losing time, then the app will make a solid impression. Design can help communicate this, even during unexpected delays.

The first step is to identify flows that will likely have delays (fetching back-end data, performing a lot of calculations, etc.). The second step is to guide users through these delays by introducing additional steps that they would perceive as being necessary (showing loading animations, displaying useful tips, etc.).

4.2. Optimize individual UI elements

Every UI element affects performance. And because every optimization contributes to overall performance, all UI elements should be considered. Key aspects to look at are:

- **Elements on screen** - The number and type of UI elements on the screen will affect the performance of that screen. For example, media items (audio, video, maps) will affect performance more than simple elements (static images, etc.).
- **Element characteristic -** The characteristics of an element, such as its resolution or image depth, affects drawing time. For example, on Android, each drawable resource (JPG, PNG) is decoded to bitmap format, so each optimized image will result in fewer kilobytes. Could you reduce the color depth? Or decrease the resolution?
- **Drawing technique -** The way a UI element is drawn by the app affects screen-loading time. For instance, is the entire background of a screen being drawn, even when a big opaque image is laid on top of it? Could a background be broken down into small tiles in order to reduce the size that needs to be uploaded?

5. Define UI Scaling Rules

Building the most appealing design is like navigating a terrain with many hurdles. It is a continual balancing act between functionality, aesthetics, usability and performance. Some platforms demand more UI compromises than others. No matter what the platform's constraints, the brand's key signatures should remain.

A UI scaling toolkit could help by communicating the relative importance of UI elements. Some elements are critical and contribute strongly to the brand's identity, while removing others will have less of an impact. Our team has established the following categories:

- **Essentials** - Essentials are the brand's core UI signatures (guideline 1). For example, the application's header.

- **Alternatives** - Alternatives are less optimal, but good for high-end solutions that put a low burden on performance. An example is replacing transparent elements with opaque ones.

- **Options** - These are elements that enhance the experience but could be removed to maintain performance. For example, reducing a list of search results on a page from 25 items to 10.

6. Use a Performance Dashboard

Clear communication among the team is critical to delivering a great product. We've encountered several situations where expectations of how a product should perform differed between marketers, designers and developers. Because performance is affected by the requirements and constraints of all of these disciplines, performance expectations need to be agreed on. As a solution, we introduced performance dashboards. These help to measure, monitor and set goals for the product's current state. Dashboards effectively communicate the product's state and the team's expectations and areas of focus. The dashboard we've used accounts for the following elements:

- **Core user stories** - Ensures that the dashboard communicates what the user experiences.
- **Benchmark** - Compares the app to a key competitor's.
- **Current measurement -** Shows the performance of the product's current implementation.
- **Goal** - Sets the performance goal for the app.
- **Status -** Indicates the current status of the app against the goal.

7. Champion Dedicated UI Engineering Skills

Design has always gone hand in hand with technology. Being able to code high-performance user experiences is a specialist's skill. It requires strong knowledge of front-end coding and a profound understanding of the design's purpose.

The implementation of layout, graphics, animation and so on will have performance implications. Of the many things that need to be considered, here are two:

- **Smart loading** - Smart-loading mechanisms, such as lazy loading, first load visible content and then move on to content below the fold. This technique reduces the user's waiting time and thus makes for a smoother experience.

- **Background loading** - This is another well-known example. Performance depends on whether the background is one large image, an amalgamation of small tiles (say, to create a texture) or a pure algorithm. The best solution depends on the situation.

In situations where responsibilities are split between the marketing, design and development teams, we've noticed that UI performance tends to fall between the cracks. Each team has its own goals, and so certain shared responsibilities, such as UI performance, lose attention. We've addressed this by including front-end coding specialists on the design team. This encourages focus on optimal UI implementation and performance, and it achieves a more advanced user experience.

Annex E. eiTV Evaluator's Observation Grid

Generation: ______ **Type of prototype (H/L):** _______ **Viewer code:** _______ **Date:** ___/___/______

	Contextual scenario		Viewers reactions			Task duration	
Task Nr	**Beginning**	**Ending**	**Comments, expectations, etc**	**Understanding of the task**	**Satisfaction with the task**	**Expected**	**Effective**
	Device: ____________ Location: ___________ Settings: ___________ Posture: ___________ Environment: _______ __________________ Distractions: ________ __________________	Device: ____________ Location: ___________ Settings: ____________ Posture: ___________ Environment: _______ __________________ Distractions: ________ __________________					
	Device: ____________ Location: ___________ Settings: ___________ Posture: ___________ Environment: _______ __________________ Distractions: ________ _________________	Device: ____________ Location: ___________ Settings: ____________ Posture: ___________ Environment: _______ __________________ Distractions: ________ __________________					

Etc…

	Observed and expressed difficulties				Help			
Task Nr	Procedures	Interface	Context	Others	Asked?	Provided	Who concluded the task?	Evaluator notes
					Y ☐ N ☐		V ☐ E ☐	
					Y ☐ N ☐		V ☐ E ☐	

Etc…

Annex F. First Generation: Script of Tasks for Viewers

1. Turn the TV on, login to the eiTV application, watch the 5 minutes CSI video. During that video visualization time:
    1.1. Stay on Level 1 information and choose 3 topics;
    1.2. Change to Level 2 information, choose a topic, watch the explanation on embedded and overlaid design and after reading the explanation don't select the topic;
    1.3. Change to Level 3 information, choose a topic, watch the list of that topic presented sub categories (watch the list on embedded and overlaid design) and select two sub categories;
2. When the final list of topics appear select one that wasn't selected during the visualization;
3. Define that you expect to receive the link with the web content location through e-mail;
4. Next, share your web content with 3 specific friends (by writing their e-mail addresses) and add a message that you consider pertinent;
5. Next, turn on the computer, go to your e-mail account and you will see that 2 web contents were generated (A and B)
6. Follow the link to the web content A:
    6.1. Watch carefully the video that appears on the left side of the text and the actions that you may apply to it;
    6.2. Watch how your TV chosen topics were ordered in the web content;
    6.3. Navigate through all web content tabs while reading the information that was made available to each selected topic.
7. Return to your e-mail and follow the link to the web content B:
    7.1. Watch carefully the video that appears on the left side of the text and the actions that you may apply to it;
    7.2. Watch how your TV chosen topics were ordered in the web content;
    7.3. Navigate through all web content tabs while reading the information that was made available to each selected topic.

Many thanks for you collaboration!

Annex G. First Generation: Questionnaire for Viewers

This questionnaire aims to collect your opinion about the tested crossmedia eiTV application. In order to try to understand if the application answers the goals that we intended to and in order to improve it, your help is absolutely needed! Thank you in advance for your participation!

Note: every collected data will be used just for what was mentioned and will be processed with confidentiality and anonymity. The average time to fill the questionnaire is around 20 minutes.

A. Personal Data

1. Code: _____ (ask this number to Prof. Alcina Prata)

2. Age: _____ Sex: ☐ Feminine ☐ Masculine

3. Your situation in terms of studies/work:

☐ Student ☐ Worker ☐ Student and Worker

Working place: ______________________________

Working function: ____________________________

Student of:

☐ ISMD ☐ MKTD ☐ HRMD ☐ Not Student

B. Interface on TV

1. Design

1.1. In what relates to the information levels 1, 2 and 3 I prefer to use (if you only like one level choose it and write 'always'. If you liked more than one, mark them and explain in what circumstances you prefer to use each one of them):

☐ Level 1 when____

☐ Level 2 when____

☐ Level 3 when____

1.2. On information levels 2 and 3 I prefer to see the information

☐ Embedded ☐ Overlaid

Because____

____

1.3. How would you define the way you adapted to this navigation interface?

☐ Very difficultly
☐ With some difficulty
☐ Average
☐ Easily
☐ Very easily

1.4. In general I consider that this interface:

	Nothing	Little	Average	Much	Very Much
Is Intuitive	☐	☐	☐	☐	☐
Is easy to use	☐	☐	☐	☐	☐
Has a fluid navigation	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Uses easy to understand keys	☐	☐	☐	☐	☐
Adapts to viewer needs (providing more or less information) and thus being flexible	☐	☐	☐	☐	☐
Is intrusive and distracts from essential	☐	☐	☐	☐	☐
Works well with the use of color keys	☐	☐	☐	☐	☐
Is adequate to create the webcontent	☐	☐	☐	☐	☐
Is adequate to conduce me to the webcontent	☐	☐	☐	☐	☐
Is easy to read					
Could be better	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐

1.5. In what relates the use of the TV interfaces and the tasks that I was assigned:

	Very Low	Low	Average	High	Very high
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
My performance (how successful was I in accomplishing what I was asked to do)?	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
how insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

1.6. In global terms I consider the TV create webcontent functionality:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It’s easy to use	☐	☐	☐	☐	☐
It’s flexible	☐	☐	☐	☐	☐
It’s easy to learn how to use	☐	☐	☐	☐	☐
I’m satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

C. Web Content through PC

1. Design

1.1. In general I consider that this interface:

	Nothing	Little	Average	Much	Very Much
Is Intuitive	☐	☐	☐	☐	☐
Is easy to use	☐	☐	☐	☐	☐
Has a fluid navigation	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Has a confused organization	☐	☐	☐	☐	☐
Allows a pleasant use experience	☐	☐	☐	☐	☐
Immediately remind the interface used on TV	☐	☐	☐	☐	☐
Allowed me to quickly understand the navigation model	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐

1.2. In my opinion the design could be improved in the following aspects:

____

____

____

1.3. In what relates the use of the webcontent and the tasks that I was assigned:

	Very Low	Low	Normal	High	Very high
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
how insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

1.4. In global terms I consider the webcontent functionality:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It’s easy to use	☐	☐	☐	☐	☐
It’s flexible	☐	☐	☐	☐	☐
It’s easy to learn how to use	☐	☐	☐	☐	☐
I’m satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

2. Contextualization

2.1. From the several contextualization options presented my favorite one was (I'm allowed to choose only **one** option):

- ☐ The **video playing** when I entered the eiTV webcontent (note: the video is from the moment of the topic choice)
- ☐ The **video stopped** when I entered the eiTV webcontent (note: the video is from the moment of the topic choice)

I prefer this option because____
____
____

2.2. The use of the contextualization referred on 2.1. (through video) is, in my opinion:

- ☐ Completely unnecessary
- ☐ Little necessary
- ☐ Necessary
- ☐ Very necessary
- ☐ Absolutely necessary

2.3. From the several contextualization options presented my favorite one was (I'm allowed to choose only **one** option):

- ☐ The **excerpt of the video** from the exact moment of the topic selection
- ☐ The **excerpt of the video** from a previous video position (few seconds) in order to include a complete sentence in the video and improve the context

2.4. As to the presentation of topics within the webcontent I prefer:

- ☐ The selection order
- ☐ The alphabetical order
- ☐ The logical order

2.5. When I entered the eiTV webcontent I had the sensation of being in the same application where I was when using the TV?

☐ Yes ☐ No

In my opinion that happened because____
____
____

2.6. As to contextualization:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
The web content contextualization succeeded	☐	☐	☐	☐	☐
The web content was capable to give continuity to the program	☐	☐	☐	☐	☐

3. Content

3.1. As to the content presented in the web content:

	Nothing	Little	Average	Much	Very Much
I agree with the level of development of the presented topics?	☐	☐	☐	☐	☐
Was the information presented on the topics adequate?	☐	☐	☐	☐	☐
Should the information presented on the topics be more developed?	☐	☐	☐	☐	☐

D. eiTV as a whole

1. Usefulness

1.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
It helps me be more effective	☐	☐	☐	☐	☐
It helps me be more productive when I watch TV	☐	☐	☐	☐	☐
It is useful	☐	☐	☐	☐	☐
It gives me more control over the information that I watch on video	☐	☐	☐	☐	☐
It makes the things I want to accomplish easier to get done	☐	☐	☐	☐	☐
It saves me time when I use it	☐	☐	☐	☐	☐
It meets my needs	☐	☐	☐	☐	☐
It does everything I would expect it to do	☐	☐	☐	☐	☐
It Comprises very useful functionalities	☐	☐	☐	☐	☐
I like to be able to access my eiTV application and its functionalities from any device	☐	☐	☐	☐	☐
I like the flexibility that the application gives me: now I can use it through the TV at home, later I continue through the smartphone on my way to school, etc	☐	☐	☐	☐	☐

2. Ease of use

2.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
It is easy to use	☐	☐	☐	☐	☐
It requires the minimum of steps to do what we want to do	☐	☐	☐	☐	☐
It is flexible	☐	☐	☐	☐	☐
It does not require effort to use	☐	☐	☐	☐	☐
May be used without the need to read instructions	☐	☐	☐	☐	☐
No inconsistencies were found while using it	☐	☐	☐	☐	☐
Both occasional and regular users will like the application	☐	☐	☐	☐	☐
It is easy and fast to recover from errors	☐	☐	☐	☐	☐
May always be used with success	☐	☐	☐	☐	☐

3. Ease of learning

3.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
I learned to use it quickly	☐	☐	☐	☐	☐
I easily remember how to use it	☐	☐	☐	☐	☐
It is easy to learn to use it	☐	☐	☐	☐	☐
I quickly become skilful with it	☐	☐	☐	☐	☐
The interfaces are intuitive	☐	☐	☐	☐	☐

4. Satisfaction

4.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
I am satisfied with it	☐	☐	☐	☐	☐
I would recommend it to friend	☐	☐	☐	☐	☐
It is fun to use	☐	☐	☐	☐	☐
It works the way I want it to	☐	☐	☐	☐	☐
It is awesome	☐	☐	☐	☐	☐
I would like to have it	☐	☐	☐	☐	☐
It is good to use	☐	☐	☐	☐	☐

5. Cognitive Overload

5.1. In what relates to the eiTV application:

	Nothing	Little	Average	Much	Very Much
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

6. In what relates eiTV I have the following comments, suggestions and critics:

____
____
____
____

7. Is there a real advantage in connecting these devices?

☐ Yes ☐ No

7.1. If your answer was 'Yes' please let us know why. Order the following reasons (use 1 to the most important reason; use 2 to the second most important reason; etc). Please don't give a number to the presented reason if you don't agree with it.

There is a real advantage in connecting these devices because:

☐ This type of application is a novelty
☐ It is interesting to have the TV connected with other devices
☐ They provide us with mobility
☐ It is fun
☐ It is different
☐ They provide us with flexibility
☐ We may access extra information about a program viewed on TV

Other reasons: ____
____

8. What other functionalities would viewers like to have in this kind of environment?

____
____
____

Many thanks for you collaboration!

Annex H. First Generation: Semi-Structured Interview

1. In relation to the tasks:
    1.1. Which task was the most difficult to accomplish? Why?
    1.2. Which task was the easiest to accomplish? Why?

2. In relation to the generated web contents:
    2.1. Which web content was your favorite? Why?
    2.2. Was it useful considering the chosen topics?
    2.3. Did you perceived the video watching interface and the generated web content as part of the same application? Why?

3. In relation to the eiTV in general:
    3.1. Is it useful? Why?
    3.2. Would you like to have it? Why?
    3.3. What could be done to improve it?

4. What other types of services, functionalities or features would you like to have in the eiTV?

5. Do you have any other suggestion?

Annex I. Second Generation: Script of Tasks for Viewers

- **PROTOTYPE A:**

1. Turn the TV on and login to the eiTV application;

2. You are now navigating through a Menu-based structure. Through that structure access the CREATE functionality in order to generate a web content on the video playing. Generate the webcontent as follows:
   2.1. Stay on Level 1 information and choose 3 topics;
   2.2. Change to Level 2 information, choose a topic, watch the explanation on embedded and overlaid design and after reading the explanation don't select the topic;
   2.3. Change to Level 3 information, choose a topic, watch the list of that topic presented sub categories (watch the list on embedded and overlaid design) and select two sub categories;
   2.4. Change to level 1 and choose information about a specific scene film shooting place and about the video producer;
   2.5. Choose the button QUIT. I will be conducted to the generic list of topics. There choose 2 topics not yet chosen, ask to be notified via e-mail and generate the web content;

3. Change to the SHARE functionality (use the color shortcut), share your web content with your Facebook contents having the attention to add a specific introductory message;

4. Next change to the SEARCH functionality (use the color shortcut) and search CSI videos with generated web contents. Choose one of the presented videos and visualize one of its web contents;

5. Next access the Webcontents functionality where you will have access to the complete list of that video web contents. Delete one of the web contents;

6. Next merge two other web contents;

7. Next change to the PROFILE functionality (use the color shortcut) and change your literacy information;

8. Turn the PC on and access your e-mail where you will find the link to the web content that you generated via TV. Watch that web content carefully;

9. Next, choose one video and watch it while generating a web content as follows:
   9.1. Stay on Level 1 information and choose 3 topics;
   9.2. Change to Level 2 information, choose a topic, watch the explanation on embedded and overlaid design and after reading the explanation don't select the topic;
   9.3. Change to Level 3 information, choose a topic, watch the list of that topic presented sub categories (watch the list on embedded and overlaid design) and select two sub categories;
   9.4. Change to level 1 and choose information about the main actress and the video director;
   9.5. Access the global list of topics and choose 2 that are not yet choosen and give up from one that was chosen while watching the video. Confirm that you will be notified through e-mail and generate the web content;

10. Next, access the Webcontents functionality and watch the generated web contents list. Follow and explore one of the web contents and at the end, return to the main list, and delete it;

11. Next try to reproduce through mobile phone what you have done through PC. Note that through the mobile phone you will need the evaluator help considering that this part of the prototype was implemented on low-fidelity.

- **PROTOTYPE B:**

Repeat exactly the same steps that you have done with prototype A.

- **TO FINISH:**

Choose your preferred prototype (A or B) and freely navigate and explore by doing whatever pleases you. However try to remember that:

a) Through TV you have the following functionalities available: Home, webcontent, CREATE, SEARCH, SHARE and PROFILE (the functionality DF is represented but inactive);

b) Through PC the following functionalities are available: Home, Webcontent and CREATE (functionality SEARCH, SHARE, PROFILE and DF are represented but inactive).

Many thanks for you collaboration!

Annex J. Second Generation: Questionnaire for Viewers

This questionnaire aims to collect your opinion about the tested crossmedia eiTV application. In order to try to understand if the application answers the goals that we intended to and in order to improve it, your help is absolutely needed! Thank you in advance for your participation!

Note: every collected data will be used just for what was mentioned and will be processed with confidentiality and anonymity. The average time to fill the questionnaire is around 20-30 minutes.

A. Personal Data

1. Code: _____ (ask this number to Prof. Alcina Prata)

2. Age: _____ Sex: ☐ Feminine ☐ Masculine

3. Your situation in terms of studies/work:

☐ Student ☐ Worker ☐Student and Worker

Working place: ______________________________

Working function: ____________________________

Student of:

☐ ISD ☐ MKD ☐ HRMD ☐ Not Student

B. Interface on TV

1. Design

1.1. In what relates to the information levels 1, 2 and 3 I prefer to use (if you only like one level choose it and write 'always'. If you liked more than one, mark them and explain in what circumstances you prefer to use each one of them):

☐ Level 1 when____

☐ Level 2 when____

☐ Level 3 when____

1.2. On information levels 1, 2 and 3 I prefer:

☐ The interface that presents the numbers meaning in a written form (see appendix 1)

☐ The interface that only presents numbers (see appendix 1)

1.3. On information levels 2 and 3 I prefer:

☐ The more graphic interface (with the Menu button and the word CREATE: see appendix 2)

☐ The more simplified interface (without both the Menu button and the word CREATE: see appendix 2)

1.4. On information levels 2 and 3 I prefer:

	At the option embedded video	**At the option overlaid video**
That the video pauses (to give me time to read the presented information)	☐	☐
That the video continues (in spite I'm reading the information that is being presented)	☐	☐

Prefer this way because: ____
____

1.5. In every screen that the video minimizes (except on information levels 2 and 3) I prefer:

☐ That the video pauses
☐ That the video keeps on playing

I prefer this way because:____
____
____

1.6. On information levels 2 and 3 I prefer to see the information

☐ Embedded ☐ Overlaid

Because____
____

1.7. In what relates the OK button I think that:

☐ The button and the caption 'Select' should appear in every screens
☐ Only the button should appear (without caption) in every screens
☐ Both button and caption should appear on first screens and, after that, only the button
☐ The button should only appear on first screens (as it happened with the navigation buttons)

1.8. During the use of the interface I needed to look to the TV remote:

☐ Every time I needed to interact
☐ Sometimes (essentially at the beginning of use)
☐ Sometimes (during the use)
☐ Few times
☐ Almost never

Why do you think that happened?____
____

1.9. During the use of this interface have you used the color buttons as shortcuts instead of using the – directional + OK - keys?

☐ Yes ☐ No

Why do you think that happened?____
____

1.10. During the use of the interface have you used buttons 1, 2 and 3 (as shortcuts) to access the different information levels instead of using – directional +OK - keys?

☐ Yes ☐ No

Why do you think that happened?____
____

1.11. How would you define the way you adapted to this navigation interface?

- ☐ Very difficultly
- ☐ With some difficulty
- ☐ Average
- ☐ Easily
- ☐ Very easily

Why do you think that happened?____

____

1.12. In general I consider that this interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is Intuitive	☐	☐	☐	☐	☐
Is easy to use	☐	☐	☐	☐	☐
Has a fluid navigation	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Uses easy to understand keys	☐	☐	☐	☐	☐
Adapts to viewer needs (providing more or less information) and thus being flexible	☐	☐	☐	☐	☐
Is intrusive and distracts from essential	☐	☐	☐	☐	☐
Works well with the use of a MENU-based system navigation	☐	☐	☐	☐	☐
Works well with the use of color keys	☐	☐	☐	☐	☐
Color keys are useful	☐	☐	☐	☐	☐
Works well with the use of underlines to show which topics may be chosen	☐	☐	☐	☐	☐
Used too many remote keys	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐
Is appropriate to create and follow extra web contents	☐	☐	☐	☐	☐

1.13. In my opinion the design could be improved in the following aspects:

____

____

2. Functionalities

2.1. Home

2.1.1. How do you classify the levels of interest of the following associated **Home** functionality possibilities?

	No interest	**Little interest**	**Average interest**	**Some intere st**	**Very interestin g**
Be able to login	☐	☐	☐	☐	☐
Be able to change viewer	☐	☐	☐	☐	☐
Be able to create new viewers account	☐	☐	☐	☐	☐
Be able to recover the password if the viewer forgets it	☐	☐	☐	☐	☐
Be able to memorize the password	☐	☐	☐	☐	☐

2.1.2. In what relates the use of the different **Home** functionality possibilities and the tasks that I was assigned:

	Very Low	Low	Normal	High	Very high
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
My performance (how successful was I in accomplishing what I was asked to do)?	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

2.1.3. In global terms I consider the **Home** functionality:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

2.1.4. In what relates to the **Home** functionality do you want to suggest anything?
____
____
____

2.2. Webcontent

2.2.1. How do you classify the levels of interest of the following associated **Webcontent** functionality possibilities?

	No interest	Little interest	Average interest	Some interest	Very interesting
Be able to see the list of webcontents	☐	☐	☐	☐	☐
Be able to delete webcontents	☐	☐	☐	☐	☐
Be able to share webcontents	☐	☐	☐	☐	☐
Be able to enter webcontents	☐	☐	☐	☐	☐
Be able to merge webcontents	☐	☐	☐	☐	☐

2.2.2. In what relates the use of the different **Webcontent** functionality possibilities and the tasks that I was assigned:

	Very Low	Low	Normal	High	Very high
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
My performance (how successful was I in accomplishing what I was asked to do)?	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

2.2.3. In global terms I consider the **Webcontent** functionality:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

2.2.4. In what relates to the Webcontent functionality do you want to suggest anything?

____

____

____

____

2.3. CREATE

2.3.1. How do you classify the levels of interest of the following associated CREATE functionality possibilities?

	No interest	Little interest	Average interest	Some interest	Very interesting
Be able to create an eiTV webcontent with extra information about the topics that are more interesting to me	☐	☐	☐	☐	☐
Split of topics into information about contents and general information	☐	☐	☐	☐	☐
Be able to opt between 3 information levels	☐	☐	☐	☐	☐
Be able to see information levels 2 and 3 overlaid or embedded	☐	☐	☐	☐	☐

2.3.2. In what relates to the 3 information levels, which one have you used more?

☐ Level 1 ☐ Level 2 ☐ Level 3

Why?____

____

In what circumstances would you use the other 2 levels? ________________________

____

2.3.3. In what relates the information visualization on 2 and 3 levels, which one have you used most?

☐ Embedded ☐ Overlaid

Why?____

____

In what circumstances would you use the other way?____

____

2.3.4. In what relates the use of the different **CREATE** functionality possibilities and the tasks that I was assigned:

	Very Low	**Low**	**Normal**	**High**	**Very high**
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
My performance (how successful was I in accomplishing what I was asked to do)?	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

2.3.5. In global terms I consider the **CREATE** functionality:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

2.3.6. In what relates to the **CREATE** functionality do you want to suggest anything?

____

____

2.4. SEARCH

2.4.1. How do you classify the levels of interest of the following associated **SEARCH** functionality possibilities?

	Nothing	Little	Average	Much	Very Much
Be able to search videos using several criteria	☐	☐	☐	☐	☐
To know in relation to the videos found if they are stored on the BOX or if they were watch from VOD	☐	☐	☐	☐	☐
To know in relation to videos found which ones have eiTV generated webcontents	☐	☐	☐	☐	☐
To the video that you select be able to see the date in which the webcontent has been generated	☐	☐	☐	☐	☐
To the video that you select be able to see the date in which the webcontent has been updated for the last time	☐	☐	☐	☐	☐
To the video that you select be able to see from which device the webcontent has been generated	☐	☐	☐	☐	☐
To the video that you select be able to see the synopsis	☐	☐	☐	☐	☐
Be able to imediatly start seying the selected video	☐	☐	☐	☐	☐
Be able to increment an existent webcontent with further information	☐	☐	☐	☐	☐

2.4.2. In what relates the use of the different **SEARCH** functionality possibilities and the tasks that I was assigned:

	Very Low	Low	Normal	High	Very High
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
My performance (how successful was I in accomplishing what I was asked to do)?	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

2.4.3. In global terms I consider the **SEARCH** functionality:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It’s easy to use	☐	☐	☐	☐	☐
It’s flexible	☐	☐	☐	☐	☐
It’s easy to learn how to use	☐	☐	☐	☐	☐
I’m satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

2.4.4. In what relates to the **SEARCH** functionality do you want to suggest anything?

____

____

2.5. SHARE

2.5.1. How do you classify the levels of interest of the following associated **SHARE** functionality possibilities?

	No interest	**Little interest**	**Average interest**	**Some interest**	**Very interesting**
Be able to immediately send the generated eiTV webcontent to my contacts	☐	☐	☐	☐	☐
Be able to send previous generated eiTV webcontents to my contacts	☐	☐	☐	☐	☐
Be able, on both cases, add my comments (ex: explain why I am sending them that webcontent)	☐	☐	☐	☐	☐
Be able to use the functionality to send comments to myself (I only need to choose Share with nobody and write in the commentary zone)	☐	☐	☐	☐	☐
To have the functionality deactivated before create or search some webcontent	☐	☐	☐	☐	☐

2.5.2. In what relates the use of the different **SHARE** functionality possibilities and the tasks that I was assigned:

	Very Low	**Low**	**Normal**	**High**	**Very high**
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
My performance (how successful was I in accomplishing what I was asked to do)?	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

2.5.3. In global terms I consider the **SHARE** functionality:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

2.5.4. In what relates to the **SHARE** functionality do you want to suggest anything? ____

2.6. PROFILE

2.6.1. How do you classify the levels of interest of the following associated **PROFILE** functionality possibilities?

	No interest	**Little interest**	**Average interest**	**Some interest**	**Very interesting**
Be able to import personal data from facebook in order to not need to fill all fields	☐	☐	☐	☐	☐
The information that needs to be inputted	☐	☐	☐	☐	☐
Be able to choose, by default, whih devices I want to use to see the webcontents	☐	☐	☐	☐	☐
Be able to choose, by default, in what way I intend to receive the link to the generated webcontent (through sms, e-mail or both)	☐	☐	☐	☐	☐

2.6.2. In what relates the use of the different **PROFILE** functionality possibilities and the tasks that I was assigned:

	Very Low	**Low**	**Normal**	**High**	**Very high**
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
My performance (how successful was I in accomplishing what I was asked to do)?	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
how insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

2.6.3. In global terms I consider the **PROFILE** functionality:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
With interesting features	☐	☐	☐	☐	☐

2.6.4. In what relates to the **PROFILE** functionality do you want to suggest anything? ____
____
____

2.7. Which one of the available functionalities do you consider more interesting?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

Why?____
____
____

2.8. Which one of the available functionalities do you consider least interesting?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

Why?____
____
____

2.9. Which one of the available functionalities do you consider more useful?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

Why?____
____
____

2.10. Which one of the available functionalities do you consider least useful?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

Why?____
____
____

2.11. Which one of the available functionalities was the most easy to use?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

Why?____
____
____

2.12. Which one of the available functionalities was the most difficult to use?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

Why?____
____
____

C. Web Interface through PC

1. Design

1.1 In general I consider that this interface:

	Nothing	Little	Average	Much	Very Much
Is Intuitive	☐	☐	☐	☐	☐
Is easy to use	☐	☐	☐	☐	☐
Has a fluid navigation	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Uses easy to understand keys	☐	☐	☐	☐	☐
It has an unclear organization	☐	☐	☐	☐	☐
Provides a good experience of use	☐	☐	☐	☐	☐
Immediately reminds the interface used on iTV	☐	☐	☐	☐	☐
Works well with the use of a MENU navigation similar to the one used on iTV	☐	☐	☐	☐	☐
Allows to quickly remember the navigation scheme	☐	☐	☐	☐	☐
Allows to quickly understand the application way of use	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐
Was well designed	☐	☐	☐	☐	☐

1.2. Which functionality did you preferred from iTV?

☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

1.3. Which functionality did you preferred from PC?

☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE

1.4. In my opinion the design could be improved in the following aspects:

____

____

2. Functionalities

2.1 In general terms and in what relates to the presented functionalities:

	Nothing	Little	Average	Much	Very Much
I felt that they were the same that I've used on TV	☐	☐	☐	☐	☐
They pleased me as much as they did when I used them through TV	☐	☐	☐	☐	☐
Are easier to use through the PC	☐	☐	☐	☐	☐
They were more interesting to use through the PC	☐	☐	☐	☐	☐
They are better design to be used through the PC	☐	☐	☐	☐	☐
They are harder to use through the PC	☐	☐	☐	☐	☐
It's good to be able to use them through different devices	☐	☐	☐	☐	☐
When entering the portal I immediately felt that I was inside the same application in spite using a different device	☐	☐	☐	☐	☐

3. Contextualization

3.1. From the several contextualization options presented my favorite one was (I'm allowed to choose only **one** option):

- ☐ The **video playing** when I entered the eiTV webcontent (note: the video is from the moment of the topic choice)
- ☐ The **video stopped** when I entered the eiTV webcontent (note: the video is from the moment of the topic choice)
- ☐ The **image** when I entered the eiTV webcontent (note: the image is from the moment of the topic choice)

I prefer this option because____
____

3.2. The use of the contextualization referred on 3.1. (through video or image) is, in my opinion:

- ☐ Completely unnecessary
- ☐ Little necessary
- ☐ Necessary
- ☐ Very necessary
- ☐ Absolutely necessary

3.3. From the several contextualization options presented my favorite one was (I'm allowed to choose only **one** option):

☐ The **excerpt of the video** from the exact moment of the topic selection

☐ The **excerpt of the video** from a previous video position (few seconds) in order to include a complete sentence in the video and improve the context

3.4. When I entered the portal where I have my eiTV webcontents I had the sensation of being in the same application where I was when using the TV?

☐ Yes ☐ No

In my opinion that happened because_______________________________________
____

3.5. In general and in what relates to the contextualization forms presented it is my belief that:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
The use of video excerpts, from the video that was being watched at the moment of the topic choice, in the eiTV webcontent helped me to understand where I was	☐	☐	☐	☐	☐
The use of an image, from the video that was being watched at the moment of the topic choice, in the eiTV webcontent helped me to understand where I was	☐	☐	☐	☐	☐
The contextualization succeeded	☐	☐	☐	☐	☐

3.6. Other possibilities that may help in terms of contextualization are:
____
____

D. eiTV as a whole

1. Usefulness

1.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
It helps me be more effective	☐	☐	☐	☐	☐
It helps me be more productive when I watch TV	☐	☐	☐	☐	☐
It is useful	☐	☐	☐	☐	☐
It gives me more control over the information that I watch on video	☐	☐	☐	☐	☐
It makes the things I want to accomplish easier to get done	☐	☐	☐	☐	☐
It saves me time when I use it	☐	☐	☐	☐	☐
It meets my needs	☐	☐	☐	☐	☐
It does everything I would expect it to do	☐	☐	☐	☐	☐
It Comprises very useful functionalities	☐	☐	☐	☐	☐
I like to be able to access my eiTV application and its functionalities from any device	☐	☐	☐	☐	☐
I like the flexibility that the application gives me: now I can use it through the TV at home, later I continue through the smartphone on my way to school, etc	☐	☐	☐	☐	☐

2. Ease of use

2.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
It is easy to use	☐	☐	☐	☐	☐
It requires the minimum of steps to do what we want to do	☐	☐	☐	☐	☐
It is flexible	☐	☐	☐	☐	☐
It does not require effort to use	☐	☐	☐	☐	☐
May be used without the need to read instructions	☐	☐	☐	☐	☐
No inconsistencies were found while using it	☐	☐	☐	☐	☐
Both occasional and regular users will like the application	☐	☐	☐	☐	☐
It is easy and fast to recover from errors	☐	☐	☐	☐	☐
May always be used with success	☐	☐	☐	☐	☐

3. Ease of learning

3.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
I learned to use it quickly	☐	☐	☐	☐	☐
I easily remember how to use it	☐	☐	☐	☐	☐
It is easy to learn to use it	☐	☐	☐	☐	☐
I quickly become skilful with it	☐	☐	☐	☐	☐
The interfaces are intuitive	☐	☐	☐	☐	☐

4. Satisfaction

4.1. In what relates to the eiTV application I think that:

	Nothing	Little	Average	Much	Very Much
I am satisfied with it	☐	☐	☐	☐	☐
I would recommend it to a friend	☐	☐	☐	☐	☐
It is fun to use	☐	☐	☐	☐	☐
It works the way I want it to	☐	☐	☐	☐	☐
It is awesome	☐	☐	☐	☐	☐
Would like to have it	☐	☐	☐	☐	☐
It is good to use	☐	☐	☐	☐	☐

5. Cognitive Overload

5.1. In what relates to the eiTV application:

	Nothing	Little	Average	Much	Very Much
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

6. In what relates eiTV I have the following comments, suggestions and critics:

____

____

____

7. Is there a real advantage in connecting these 3 devices?

☐ Yes ☐ No

7.1. If your answer was 'Yes' please let us know why. Order the following reasons (use 1 to the most important reason; use 2 to the second most important reason; etc). Please don't give a number to the presented reason if you don't agree with it.

There is a real advantage in connecting these devices because:

☐ This type of application is a novelty
☐ It is interesting to have the TV connected with other devices
☐ They provide us with mobility
☐ It is fun
☐ It is different
☐ They provide us with flexibility
☐ We may access extra information about a video

Other reasons: ____
____

8. Continuity

8.1. When I accessed the portal through the different devices I had the immediate sensation of being in the same application.

☐ Yes ☐ No

In my opinion that happened because_______________________________________
____

9. Only answer the next questions if you have evaluated the previous version of the eiTV application:

9.1. Comparatively to the previous eiTV version I consider this version:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
More intuitive	☐	☐	☐	☐	☐
More user friendly	☐	☐	☐	☐	☐
More flexible	☐	☐	☐	☐	☐
Has better interfaces	☐	☐	☐	☐	☐
Pleases me more	☐	☐	☐	☐	☐
Has more useful functionalities	☐	☐	☐	☐	☐
It is easier to learn in spite implying the use of more devices and functionalities	☐	☐	☐	☐	☐

9.2. Comparatively to the previous eiTV version I consider that:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
These functionalities are more useful	☐	☐	☐	☐	☐
The contextualization was better achieved	☐	☐	☐	☐	☐
I like to see the screens with less written instructions (ex: to explain how to navigate)	☐	☐	☐	☐	☐
The functionalities presentation in a menu-based works well	☐	☐	☐	☐	☐
The inclusion of a SEARCH functionality was a good idea	☐	☐	☐	☐	☐
The use of a unique portal where all the webcontents are aggregated was a good idea	☐	☐	☐	☐	☐
It is good to be abble to use, through the PC, all the functionalities that were available through the TV	☐	☐	☐	☐	☐

Many thanks for you collaboration!

Annex K. Second Generation: Semi-Structured Interview

1. In relation to the tasks:

    1.1. Which task was the most difficult to accomplish? Why?

    1.2. Which task was the easiest to accomplish? Why?

2. In relation to the available functionalities (Home, Webcontent, Create, Search, Share and Profile) which one:

    2.1. Was easier to use?

    2.2. Was the most difficult to use?

    2.3. Was the most useful?

    2.4. Was the least useful?

3. Did you enjoy the idea of a portal? Why?

4. Did you like the evolution that occurred from the first to the second generation? Why?

    4.1. What did you appreciate the most in this transition from first to second generation?

5. In relation to the generated web contents:

    5.1. Which web content was your favorite? Why?

    5.2. Was it useful considering the chosen topics?

    5.3. Did you perceived the video watching interface and the generated web content as part of the same application? Why?

6. In relation to the eiTV in general:

    6.1. Is it useful? Why?

    6.2. Would you like to have it? Why?

    6.3. What could be done to improve it?

    6.4. Do you think that the difficulty level increased too much? Why?

7. What other types of services, functionalities or features would you like to have in the eiTV?

8. Do you have any other suggestion?

Annex L. Third Generation: Script of Tasks for Viewers

1. Turn the TV on, login to the eiTV application, watch a 10 minutes CSI video, and generate a web content with:
   1.1. Five topics from those that appear underlined;
   1.2. Two personalized topics (words that are not underlined but that you may also want to know more about);
   1.3. Data that appears written below someone on the video;
   1.4. Information about the place were a specific scene was filmed;

   Share the web content with 2 friends (by writing their e-mail addresses) and add a specific message to them.

2. Turn on the PC, access the eiTV application via the provided desktop icon and login. After login to the eiTV application, ask to work on your desktop (living your eiTV minimized but activated). Check your e-mail and follow the web content link that you have just created (on 1.). On the first tab from your left side, do the following procedures:
   2.1. Edit the first paragraph by adding a small phrase about the dangers of fire. Then define that paragraph as private;
   2.2. Move your second paragraph in order to put it below the third one and define it as visible only to your friends;
   2.3. Import an audio file stored on the PC to any tab at your choice and define it as visible only to one person (which e-mail address you will have to write);
   2.4. Next, and from the web content, ask to see the video that first originate that web content;
   2.5. While watching that video (for the second time) see the associated metadata and generate another web content;

3. Next, go to the school yard with the mobile phone and login to the eiTV. Use the DF functionality to:
   3.1. Create a small video about the school building;
   3.2. Use the GPS coordinates of that video in order to try to find related videos and images (through the option '**Search by GPS**');
   3.3. If you find some video, watch it and then add it to your tab 'Myinput generic' (through the use of the option '**export to eiTV'**). In case you don't find any related video, add your own video;

3.4. Next, enter the school and take a picture of the first fire extinguisher that you find. Manually insert the metadata 'fire' and 'fire extinguisher' on that picture (through the option '**add metadata'**). Next, search videos and images related to fire and fire extinguishers (through the option '**search by metadata'**). If you find some related videos, choose one and add it to your web content, just below the place where you have added a phrase about fire. If you don't find any related video, than insert, on that same place, the picture that you just took from the fire extinguisher. Independently of what you will be able to add, that content should be defined as public.

3.5. Then go to the school bar. While waiting at the end of the queue bar add the GPS coordinates of that place to the web content (generated in 1.) in any tab at your choice (note that those coordinates should be visible only for you);

3.6. Next, go to the library, search one of your CSI videos with generated web contents (through the SEARCH functionality) and watch the video. After some time watching the video choose one of its associated web contents and watch it instead. From there please activate the edition mode in order to be able to delete a block of information.

4. Keep your mobile phone connected and turn on the PC. Use the mobile phone to search CSI videos with generated web contents (through the SEARCH functionality). Synchronise the mobile phone with the PC. Use the mobile phone to watch the video while using the computer as a complementary device in order to see one of the related web contents.

Many thanks for you collaboration!

Annex M. Third Generation: Questionnaire for Viewers

This questionnaire aims to collect your opinion about the tested crossmedia eiTV application. In order to try to understand if the application answers the goals that we intended to and in order to improve it, your help is absolutely needed! Thank you in advance for your participation!

Note: every collected data will be used just for what was mentioned and will be processed with confidentiality and anonymity. The average time to fill the questionnaire is around 20 minutes.

A. Personal Data

1. Code: _____ (ask this number to Prof. Alcina Prata)
2. Age: _____ Sex: ☐ Feminine ☐ Masculine
3. Your situation in terms of studies/work:

☐ Student ☐ Worker ☐Student and Worker

Working place: ______________________________

Working function: ____________________________

Student of:

☐ ISD ☐ MKD ☐ HRMD ☐ Not Student

B. Interface on iTV

1. Design

1.1. How would you define the way you adapted to this navigation interface?

- ☐ Very difficultly
- ☐ With some difficulty
- ☐ Average
- ☐ Easily
- ☐ Very easily

Why do you think that happened? ____

____

1.2. Which one of the available functionalities was the most easy to use?

☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE ☐ DF

Why? ____

____

1.3. Which one of the available functionalities was the most difficult to use?

☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE ☐ DF

Why?____

____

1.4. On iTV **departure** Interface which was the most used Information level? (only choose one option):

☐ Level 1 ☐ Level 2 ☐ Level 3

1.5. As **departure** Interface I consider the iTV interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is easy to learn	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐

1.6. As **arrival** Interface I consider the iTV interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is easy to learn	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐

1.7. In **general** I consider that the iTV interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is Intuitive	☐	☐	☐	☐	☐
Is easy to use	☐	☐	☐	☐	☐
Has a fluid navigation	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Uses easy to understand keys	☐	☐	☐	☐	☐
Adapts to viewer needs (providing more or less information)	☐	☐	☐	☐	☐
Is intrusive and distracts from essential	☐	☐	☐	☐	☐
Works well with the use of a MENU navigation	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐

1.8. In my opinion the design could be improved in the following aspects:
____
____
____

B. Interface on PC

1. Design

1.1. How would you define the way you adapted to this navigation interface?

- ☐ Very difficultly
- ☐ With some difficulty
- ☐ Average
- ☐ Easily
- ☐ Very easily

Why do you think that happened? ____
____

1.2. Which one of the available functionalities was the most easy to use?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE ☐ DF

Why? ____
____
____

1.3. Which one of the available functionalities was the most difficult to use?
☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE ☐ DF

Why?____
____
____

1.4. On PC **departure** Interface which was the most used Information level? (only choose one option):

☐ Level 1 ☐ Level 2 ☐ Level 3

1.5. As **departure** Interface I consider the PC interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is easy to learn	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐

1.6. As **arrival** Interface I consider the PC interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is easy to learn	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐

1.7. In **general** I consider that the PC interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is Intuitive	☐	☐	☐	☐	☐
Is easy to use	☐	☐	☐	☐	☐
Has a fluid navigation	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Uses easy to understand keys	☐	☐	☐	☐	☐
Adapts to viewer needs (providing more or less information)	☐	☐	☐	☐	☐
Is not intrusive and does not distract from essential	☐	☐	☐	☐	☐
Works well with the use of a MENU-based system	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐

1.8. In my opinion the design could be improved in the following aspects:
____

____
____

C. Interface on Mobile Device

1. Design

1.1. How would you define the way you adapted to this navigation interface?

- ☐ Very difficultly
- ☐ With some difficulty
- ☐ Average
- ☐ Easily
- ☐ Very easily

Why do you think that happened? ____
____
____

1.2. Which one of the available functionalities was the most easy to use?

☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE ☐ DF

Why? ____
____
____

1.3. Which one of the available functionalities was the most difficult to use?

☐ Home ☐ Webcontent ☐ CREATE ☐ SEARCH ☐ SHARE ☐ PROFILE ☐ DF

Why?____
____
____

1.4. On Mobile Device **departure** Interface which was the most used Information level? (only choose one option):

☐ Level 1 ☐ Level 2 ☐ Level 3

1.5. As **departure** Interface I consider the Mobile Device interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is easy to learn	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐

1.6. As **arrival** Interface I consider the Mobile Device interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is easy to learn	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐

1.7. In **general** I consider that the Mobile Device interface:

	Nothing	**Little**	**Average**	**Much**	**Very Much**
Is Intuitive	☐	☐	☐	☐	☐
Is easy to use	☐	☐	☐	☐	☐
Has a fluid navigation	☐	☐	☐	☐	☐
Is visually pleasant	☐	☐	☐	☐	☐
Uses easy to understand keys	☐	☐	☐	☐	☐
Adapts to viewer needs (providing more or less information)	☐	☐	☐	☐	☐
Is not intrusive and does not distract from essential	☐	☐	☐	☐	☐
Works well with the use of a MENU-based system	☐	☐	☐	☐	☐
Could be better	☐	☐	☐	☐	☐
Is well designed	☐	☐	☐	☐	☐

1.8. In my opinion the design could be improved in the following aspects:

____

____

____

C. Functionalities

1. DF

1.1. How do you classify the <u>levels of interest</u> of the following associated **DF** functionality possibilities?

	No interest	**Little interest**	**Average interest**	**Some interest**	**Very interesting**
Be able to minimize the eiTV application without exit	☐	☐	☐	☐	☐
Be able to add GPS coordinates to Myinput tab or specific webcontent	☐	☐	☐	☐	☐
Be able to synchronized devices	☐	☐	☐	☐	☐
Be able to use videos (from the gallery or recorded at that moment) in order to:					
a) Add metadata	☐	☐	☐	☐	☐
b) Search by metadata	☐	☐	☐	☐	☐
c) Search by GPS	☐	☐	☐	☐	☐
d) Export to eiTV	☐	☐	☐	☐	☐
Be able to use pictures (from the gallery or taken at that moment) in order to:					
a) Add metadata	☐	☐	☐	☐	☐
b) Search by metadata	☐	☐	☐	☐	☐
c) Search by GPS	☐	☐	☐	☐	☐
d) Export to eiTV	☐	☐	☐	☐	☐
Be able to import other files to the eiTV, namely:					
a) Audio files	☐	☐	☐	☐	☐
b) SMS	☐	☐	☐	☐	☐
c) MMS	☐	☐	☐	☐	☐

1.2. How do you classify the difficulty level of the following associated **DF** functionality possibilities?

	Very difficult	Little difficult	Average	Easy	Very Easy
Minimize the eiTV application without exit	☐	☐	☐	☐	☐
Add GPS coordinates to Myinput tab or specific webcontent	☐	☐	☐	☐	☐
Synchronize devices	☐	☐	☐	☐	☐
Use videos (from the gallery or recorded at that moment) in order to:					
a) Add metadata	☐	☐	☐	☐	☐
b) Search by metadata	☐	☐	☐	☐	☐
c) Search by GPS	☐	☐	☐	☐	☐
d) Export to eiTV	☐	☐	☐	☐	☐
Use pictures (from the gallery or taken at that moment) in order to:					
a) Add metadata	☐	☐	☐	☐	☐
b) Search by metadata	☐	☐	☐	☐	☐
c) Search by GPS	☐	☐	☐	☐	☐
d) Export to eiTV	☐	☐	☐	☐	☐
Import other files to the eiTV, namely:					
a) Audio files	☐	☐	☐	☐	☐
b) SMS	☐	☐	☐	☐	☐
c) MMS	☐	☐	☐	☐	☐

1.3. What do you think about the need to insert metadata manually? ____

1.4. In what relates the use of the different **DF** functionality possibilities and the tasks that I was assigned:

	Nothing	Little	Average	Much	Very Much
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

1.5. In global terms I consider the **DF** functionality:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
Available features interesting	☐	☐	☐	☐	☐

1.6. In what relates to the **DF** functionality do you want to suggest anything?

____

2. Webcontent

2.1. How do you classify the <u>levels of interest</u> of the following associated **Webcontent** functionality possibilities?

	No interest	Little interest	Average interest	Some interest	Very interesting
Be able to see the list of webcontents	☐	☐	☐	☐	☐
Be able to delete webcontents	☐	☐	☐	☐	☐
Be able to share webcontents	☐	☐	☐	☐	☐
Be able to enter the webcontents	☐	☐	☐	☐	☐
Be able to merge webcontents	☐	☐	☐	☐	☐
Be able to see the webcontent source video	☐	☐	☐	☐	☐
Be able to move pieces of information	☐	☐	☐	☐	☐
Be able to edit pieces of information	☐	☐	☐	☐	☐
Be able to delete pieces of information	☐	☐	☐	☐	☐
Be able to import internal and external information to the webcontent	☐	☐	☐	☐	☐
Be able to define different privacy status to each piece of information	☐	☐	☐	☐	☐

2.2. How do you classify the <u>difficulty level</u> of the following associated **Webcontent** functionality possibilities?

	Very difficult	Little difficult	Average	Easy	Very Easy
See the list of webcontents	☐	☐	☐	☐	☐
Delete webcontents	☐	☐	☐	☐	☐
Share webcontents	☐	☐	☐	☐	☐
Enter the webcontents	☐	☐	☐	☐	☐
Merge webcontents	☐	☐	☐	☐	☐
See the webcontent source video	☐	☐	☐	☐	☐
Move pieces of information	☐	☐	☐	☐	☐
Edit pieces of information	☐	☐	☐	☐	☐
Delete pieces of information	☐	☐	☐	☐	☐
Import internal and external information to the webcontent	☐	☐	☐	☐	☐
Define different privacy status to each piece of information	☐	☐	☐	☐	☐

2.3. In what relates the use of the different **Webcontent** functionality possibilities and the tasks that I was assigned:

	Very Low	Low	Average	High	Very high
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

2.4. In global terms I consider the **Webcontent** functionality:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
Available features interesting	☐	☐	☐	☐	☐

2.5. In what relates to the **Webcontent** functionality do you want to suggest anything?

____

____

____

3. CREATE

3.1. How do you classify the levels of interest of the **CREATE** functionality NEW possibilities?

	No interest	Little interest	Average interest	Some interest	Very interesting
Let the viewer choose extra topics beyond those that are underlined	☐	☐	☐	☐	☐
Sends an e-mail to viewers friends every time that a webcontent that was sent to them is edited	☐	☐	☐	☐	☐

3.2. How do you classify the difficulty level of the **CREATE** functionality NEW possibilities?

	Very difficult	Little difficult	Average	Easy	Very easy
Let the viewer choose extra topics beyond those that are underlined	☐	☐	☐	☐	☐
Deactivate sending e-mail to viewers friends every time that a webcontent that was send to them is edited	☐	☐	☐	☐	☐

3.3. In what relates the use of the NEW **CREATE** functionality possibilities and the tasks that I was assigned:

	Very Low	Low	Average	High	Very high
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

3.4. In global terms I consider the NEW **CREATE** functionality possibilities:

	Nothing	Little	Average	Much	Very Much
Useful	☐	☐	☐	☐	☐
It covers my needs	☐	☐	☐	☐	☐
It's easy to use	☐	☐	☐	☐	☐
It's flexible	☐	☐	☐	☐	☐
It's easy to learn how to use	☐	☐	☐	☐	☐
I'm satisfied for having it	☐	☐	☐	☐	☐
Available features interesting	☐	☐	☐	☐	☐

3.5. In what relates to the NEW **CREATE** functionality do you want to suggest anything?

____
____
____
____
____

D. eiTV as a whole

1. Usefulness

1.1. In what relates to the eiTV application in general I think that:

	Nothing	Little	Average	Much	Very Much
It helps me be more effective	☐	☐	☐	☐	☐
It helps me be more productive when I watch video	☐	☐	☐	☐	☐
It is useful	☐	☐	☐	☐	☐
It gives me more control over the information that I watch on video	☐	☐	☐	☐	☐
It makes the things I want to accomplish easier to get done	☐	☐	☐	☐	☐
It saves me time when I use it	☐	☐	☐	☐	☐
It meets my needs	☐	☐	☐	☐	☐
It does everything I would expect it to do	☐	☐	☐	☐	☐
It comprises very useful functionalities	☐	☐	☐	☐	☐
I like to be able to access my eiTV application and its functionalities from any device	☐	☐	☐	☐	☐
I like the flexibility that the application gives me: now I can use it through the TV at home, later I continue through the smartphone on my way to school, etc	☐	☐	☐	☐	☐

2. Ease of use

2.1. In what relates to the eiTV application in general I think that:

	Nothing	Little	Average	Much	Very Much
It is easy to use	☐	☐	☐	☐	☐
It requires the minimum of steps to do what we want to do	☐	☐	☐	☐	☐
It is flexible	☐	☐	☐	☐	☐
It does not require effort to use	☐	☐	☐	☐	☐
May be used without the need to read instructions	☐	☐	☐	☐	☐
No inconsistencies were found while using it	☐	☐	☐	☐	☐
Both occasional and regular users will like the application	☐	☐	☐	☐	☐
It is easy and fast to recover from errors	☐	☐	☐	☐	☐
May always be used with success	☐	☐	☐	☐	☐

3. Ease of learning

3.1. In what relates to the eiTV application in general I think that:

	Nothing	Little	Average	Much	Very Much
I learned to use it quickly	☐	☐	☐	☐	☐
I easily remember how to use it	☐	☐	☐	☐	☐
It is easy to learn to use it	☐	☐	☐	☐	☐
I quickly become skilful with it	☐	☐	☐	☐	☐
The interfaces are intuitive	☐	☐	☐	☐	☐

4. Satisfaction

4.1. In what relates to the eiTV application in general I think that:

	Nothing	Little	Average	Much	Very Much
I am satisfied with it	☐	☐	☐	☐	☐
I would recommend it to a friend	☐	☐	☐	☐	☐
It is fun to use	☐	☐	☐	☐	☐
It works the way I want it to	☐	☐	☐	☐	☐
It is awesome	☐	☐	☐	☐	☐
I would like to have it	☐	☐	☐	☐	☐
It is good to use	☐	☐	☐	☐	☐

5. Cognitive Overload

5.1. In what relates to the eiTV application:

	Nothing	Little	Average	Much	Very Much
How mentally demanding were the tasks?	☐	☐	☐	☐	☐
How physically demanding were the tasks?	☐	☐	☐	☐	☐
The temporal effort I had to do in order to not take too much time	☐	☐	☐	☐	☐
How hard did I have to work to accomplish my level of performance?	☐	☐	☐	☐	☐
How insecure, discouraged, irritated, stressed and annoyed was I?	☐	☐	☐	☐	☐

6. In what relates eiTV I have the following comments, suggestions and critics:

____

____

____

____

____

7. Is there a real advantage in connecting these 3 devices?

☐ Yes ☐ No

7.1. If your answer was 'Yes' please let us know why. Order the following reasons (use 1 to the most important reason; use 2 to the second most important reason; etc). Please don't give a number to the presented reason if you don't agree with it.

There is a real advantage in connecting these devices because:

- ☐ This type of application is a novelty
- ☐ It is interesting to have the TV connected with other devices
- ☐ They provide us with mobility
- ☐ It is fun
- ☐ It is different
- ☐ They provide us with flexibility
- ☐ We may access extra information about a video

Other reasons: ____

____

8. Continuity

8.1. When I accessed the portal through the different devices I had the immediate sensation of being in the same application.

☐ Yes ☐ No

In my opinion that happened because____________________________________

____

8.2. To have different available options depending on the device being used:

	Nothing	Little	Average	Much	Very Much
Confused me	☐	☐	☐	☐	☐
Was interesting	☐	☐	☐	☐	☐
Makes sense	☐	☐	☐	☐	☐

In my opinion that happened because____________________________________

____

9. Only answer the next questions if you have evaluated the previous version of the eiTV application:

9.1. Comparatively to the previous eiTV version I consider this version:

	Nothing	Little	Average	Much	Very Much
More intuitive	☐	☐	☐	☐	☐
More user friendly	☐	☐	☐	☐	☐
More flexible	☐	☐	☐	☐	☐
Has better interfaces	☐	☐	☐	☐	☐
Pleases me more	☐	☐	☐	☐	☐
Has more useful functionalities	☐	☐	☐	☐	☐
It is easier to learn in spite implying the use of more devices and functionalities	☐	☐	☐	☐	☐

9.2. Comparatively to the previous eiTV version I consider that:

	Nothing	Little	Average	Much	Very Much
The new functionalities contributed to improve the eiTV application	☐	☐	☐	☐	☐
The contextualization was better achieved	☐	☐	☐	☐	☐
The continuity was better achieved	☐	☐	☐	☐	☐
The use of a unique portal where all the webcontents are aggregated was a good idea	☐	☐	☐	☐	☐
It is good to be abble to use, through the mobile phone, all the functionalities that were available through the TV and PC	☐	☐	☐	☐	☐

Many thanks for you collaboration!

Annex N. Third Generation: Semi-Structured Interview

1. In relation to the tasks:
   1.1. Which task was the most difficult to accomplish? Why?
   1.2. Which task was the easiest to accomplish? Why?
2. In relation to the DF functionality:
   2.1. Was it confusing to have different features from DF depending on the device being used?
   2.2. Did you enjoy searching by GPS (location-based search)? Why?
   2.3. Was it useful to be able to search by GPS?
   2.4. Did you enjoy searching by metadata (content-based search)? Why?
   2.5. Was it useful to be able to search by metadata?
   2.6. Did you enjoy the possibility to add additional files to your web content?
   2.7. Did you enjoy having a link to the original video?
3. In relation to the generated web contents:
   3.1. Is it useful to be able to edit every piece of information?
   3.2. Did you perceived the video watching interface and the generated web content as part of the same application in spite the different devices used? Why?
4. In relation to the eiTV in general:
   4.1. Did you like the evolution that occurred since the first prototype?
   4.2. Is the eiTV useful? Why?
   4.2. Would you like to have it? Why?
   4.3. What could be done to improve it?
   4.4. Do you think that the level of difficulty increased too much along generations?
   4.5. Did you enjoy the synchronization of devices? Why?
   4.6. Did you enjoy the possibility to use the application in a ‘second screen’ mode?
   4.7. The changes in context of use were confusing?
   4.8. Were the available extra topics useful?
5. What other types of services, functionalities or features would you like to have in the eiTV?
6. Do you have any other suggestion?

Annex O. eiTV Technical Dimension

For the eiTV application a Client-server architecture was followed. The server is an important part of the application considering that without it nothing would be possible. Completely developed with **PHP** and with the database in **MySQL**, the server stores and feeds the application with all the information needed (as keywords and web contents), and allows validations (as viewers logins).

These are its three main functionalities:

- Loadmovies: responsible for downloading videos from the database and send them to the application. The script is available at Annex O1;
- Loadsubs: responsible for the subtitles interpretation and their download to the application with the correspondent topics (script available in Annex O2);
- Submit: responsible for generating the web contents and store all the information, as for e.g. the chosen topics and the video where they belong (script available in AnnexO3).

As to the client side, the web contents, after being generated are shown in an **HTML** page, with animations created in **JavaScript** and design configured by **CSS**.

There is a main file that is the ‘heart’ of the application. It connects to the server, assures the viewer login (completely managed by the server) and returns all the information needed as: list of videos, topics, subtitles, web contents, viewers’ information, etc. This file is also responsible by mapping the TV remote keys to the desired specific actions. By analyzing a configuration XML file, the file associates each key to the keys that are configured on the remote. The script is available in Annex O4.

Another important file is the one responsible for managing the subtitles. This is the ActionScrit object that analyses the video and synchronizes it with the available subtitles on screen. This code converts movie frames into seconds, and when the second matches the subtitle, it displays the subtitles on screen with the selectable topics. The script is available in Annex O5.

An example of a GPS return file is also included in Annex O6. This is a dynamic code which is generated in real time. This allows its dynamic adaptation to the different situation of the smartphone.

Many other types of files and scripts were used, but considering that the technical dimension is not within the scope of this thesis, we have included some of the most representative in order to exemplify the technical work involved in the development of the used prototypes.

Annex O1. Functionality Loadmovies

```
<?php
	include("includes/connection.php");

	$filmes = AcessDB::selectFromDataBase("SELECT * FROM filme");

	header("Expires: Thu, 01 Jan 1970 00:00:00 GMT, -1 ");
	header("Cache-Control: no-cache, no-store, must-revalidate");
	header("Pragma: no-cache");

	echo '<?xml version="1.0" encoding="iso-8859-1"?>'."\n";

	echo '<filmes>'."\n";
	for($i=0,$i_s=sizeof($filmes);$i<$i_s;$i++)
	{
			echo "\t".'<filme'.

	// ' id="'.$filmes[$i]->filme_id.'"'.
	//' nome="'.$filmes[$i]->filme_name.'" '.
	//' target="'.$filmes[$i]->filme_target_file.'"'.
	//' descricao="'.$filmes[$i]->desricao_filme .'" '.

					'>'.$i.'</filme>'."\n";
	}
	echo '</filmes>';
?>
```

Annex O2. Functionality Load Sub

```
<?php
	include_once("includes/connection.php");

	$loaded = FALSE;

	if(!isset($filme))
		$filme = $_GET['movie'];
	else
		$loaded = TRUE;

	$filme_data = AcessDB::selectFromDataBase("SELECT * FROM filme
WHERE filme_target_file='".$filme."'");
	$filme_data=$filme_data[0];

//
	$legenda = explode('.',$filme);
	$legenda = $legenda[0].".srt";

	$file = file("legendas/".$legenda);

	$legendas=array();
	$l=-1;

	for($i=0,$i_s=sizeof($file);$i<$i_s;$i++)
	{
		//limpar dados nÃ£o necessarios
		if(trim($file[$i])==NULL)
		{
			unset($file[$i]);
			continue;
		}

		if(is_numeric(trim($file[$i])))
		{
			$legenda_id = trim($file[$i]);
			unset($file[$i]);
			continue;
		}


		//tira tempos
		if(strstr($file[$i],"-->")!==false)
		{
			$tempos = explode("-->",$file[$i]);

			for($j=0;$j<2;$j++)
			{
				switch($j)
				{
					case 0:
						$titulo='inicio';
					break;
					case 1:
						$titulo='fim';
					break;
				}
```

```
                                $horas=explode(":",$tempos[$j]);

                                for($t=0;$t<3;$t++)
                                {
                                        switch($t)
                                        {
                                                case 0:
                                                        $titulo2='h';
                                                break;
                                                case 1:
                                                        $titulo2='m';
                                                break;
                                                case 2:
                                                        $titulo2='s';
                                                break;
                                        }
                                        $h = trim($horas[$t]);

                                        if($pos=strstr($h,",")!==false)
                                                $h=substr($h,0,$pos+1);

                                        $horas_final[$titulo2]=$h;

                                }

                                $tempo_final[$titulo]=$horas_final;
                        }

                        $l++;
                        $legendas[$l]=$tempo_final;

                        continue;
                }

                $legenda_texto = $file[$i];

                $sql    =    "SELECT    *    FROM    palavras_chave    WHERE
legenda_id=$legenda_id AND filme_id=".$filme_data->filme_id;
                $palavra = AcessDB::selectFromDataBase($sql);

                $palavra_id = 0;
                if($palavra!==FALSE)
                {
                        $palavra = $palavra[0];
                        $palavra_id = (int) $palavra->palavra_id;

                        $sql  =  "SELECT  *  FROM  palavras_topicos  WHERE
palavra_id=".$palavra_id." AND topico_ordem = 1";

                        $descricao = AcessDB::selectFromDataBase($sql);

                        if($descricao!==FALSE)
                        {
                        $descricao=$descricao[0];
                        $legendas[$l]['descricao']=$descricao-
>topico_texto;
                        }


                        $legendas[$l]['palavra_id']=$palavra-
>palavra_id;
```

```
		$palavra_chave = $palavra->palavra_nome;

		$palavra_chave_alt = '-|u|-'.$palavra_chave.'-|/u|-';

		$legenda_texto                                    =
str_replace($palavra_chave,$palavra_chave_alt,$legenda_texto);

		$legendas[$l]['palavra_nome']=$palavra_chave;
		}

		if($loaded===TRUE && $palavra_id==0)
		{
			unset($legendas[$l]);
			continue;
		}


		$legendas[$l]['legenda_id']=$legenda_id;

		if(isset($legendas[$l]['legenda'])===false)
			$legendas[$l]['legenda']=array();

		array_push($legendas[$l]['legenda'],$legenda_texto);
	}

  //cria XML

	if($loaded===FALSE)
	{
		header("Expires: Thu, 01 Jan 1970 00:00:00 GMT, -1 ");
		header("Cache-Control:   no-cache,   no-store,   must-
revalidate");
		header("Pragma: no-cache");


		echo    '<?xml    version="1.0"    encoding="iso-8859-
1"?>'."\n";

		echo '<legendas>'."\n";

		for($i=0,$i_s=sizeof($legendas);$i<$i_s;$i++)
		{
			echo                          "\t".'<legenda
id="'.$legendas[$i]['legenda_id'].'">'."\n";

				if(isset($legendas[$i]['descricao']))
				{
					echo
"\t"."\t".'<descricao>'.$legendas[$i]['descricao'].'</descricao>'."\n"
;
				}

				if(isset($legendas[$i]['palavra_id']))
				{
					echo         "\t"."\t".'<palavra
id="'.$legendas[$i]['palavra_id'].'"
nome="'.$legendas[$i]['palavra_nome'].'"></palavra>'."\n";
				}
```

```
                              echo                "\t"."\t".'<time_start
h="'.$legendas[$i]['inicio']['h'].'" '.

'm="'.$legendas[$i]['inicio']['m'].'" '.

's="'.$legendas[$i]['inicio']['s'].'">'.

'</time_start>'."\n";

  echo "\t"."\t".'<time_end h="'.$legendas[$i]['fim']['h'].'" '.

  'm="'.$legendas[$i]['fim']['m'].'" '.

's="'.$legendas[$i]['fim']['s'].'">'.

        '</time_end>'."\n";

                echo "\t"."\t".'<textos>'."\n";

                foreach($legendas[$i]['legenda'] as $leg)
                              {
                              $leg=str_replace('<i>','',$leg);

        $leg=str_replace('</i>','',$leg);
                                      echo
"\t"."\t"."\t".'<texto>'.trim($leg).'</texto>'."\n";
                              }

                              echo "\t"."\t".'</textos>'."\n";

                      echo "\t".'</legenda>'."\n";

                }

                echo '</legendas>'."\n";
        }


  ?>
```

Annex O3. Functionality Submit

```
<?php
	include("includes/connection.php");
	require_once($_SERVER['DOCUMENT_ROOT']."/includes/sendSMTPmail.
php");

	//inicia save
	if($_POST['action']=='save')
	{
		$save=array();
		$valores=array();
		$valores['user_id']=$_POST['user_id'];
		$valores['session_exmails']=$_POST['emails'];
		$valores['filme_id']=$_POST['filme_id'];
		$valores['session_comentarios']=$_POST['comentarios'];
		$valores['session_date']=time();


	$sql=AcessDB::insertToDataBase("sessions",$valores,TRUE);
		array_push($save,$sql);

		foreach($_POST as $ind=>$val)
		{
			$dados=array();
			$valores=array();
			//Ã© uma palavra
			if(strstr($ind,"palavra")!== FALSE)
			{
				$dados=explode("/",$val);

				$dados[1]=(int)$dados[1];

				if($dados[1]<=0)
					$dados[1]=NULL;


	$valores['session_id']=":SQL=LAST_INSERT_ID();:";
				$valores['palavra_id']=$dados[0];
				$valores['display_id']=$dados[1];
				$valores['ordem']=$dados[2];



$sql=AcessDB::insertToDataBase("sessions_selections",$valores,TRUE);
				array_push($save,$sql);
			}

		}

		$ret=AcessDB::makeTransactions($save);

		if($ret===TRUE)
		{
			echo "SAVED";

			$id=AcessDB::getNextAutoIncrement("sessions");

			$id--;
```

```
                    $data['LICAO']=$id;
                    $data['COMENT']=$_POST['comentarios'];

                    $mail=getEmail("licao",$data);

                    if($_POST['sendmail']==1)
                    {

                            if($_POST['emails']!=NULL)
                            {

        $cc=str_replace("\r",",",$_POST['emails']);
                                    $cc=str_replace("\n",",",$cc);

                                    $cc=str_replace(" ",",",$cc);
                                    $cc=str_replace(",,",",",$cc);

                                    $cc=str_replace(";",",",$cc);
                                    $cc=str_replace(";;",",",$cc);

                                    $explode_cc=explode(",",$cc);
                            }


   $user=   AcessDB::selectFromDataBase("SELECT   *   FROM   user   WHERE
user_id=".$_POST['user_id']);

        $emails=array();
        array_push($emails,$user[0]->user_email);

        if(is_array($explode_cc))

        $emails=array_merge($emails,$explode_cc);


                sendSMTPmail($emails,"LiÃ§Ã£o eiTV",$mail,FALSE);
                        }
                }
                else
                        echo $ret;


        }
        elseif($_POST['action']=="login")
        {
        $user= AcessDB::selectFromDataBase("SELECT * FROM user WHERE
user_pin=".$_POST['pin']);

                if(is_array($user) && sizeof($user)>0)
                {
                echo "status=OK&".
                 "id=".$user[0]->user_id."&".
                 "sex=".$user[0]->user_sex."&".
                 "nascimento=".$user[0]->user_nascimento."&".
                 "habilitacoes=".$user[0]->user_habilitacoes."&".
                 "telemovel=".$user[0]->user_telemovel."&".
                 "user_email=".$user[0]->user_email."&".
                 "nome=".$user[0]->user_name;

        $user_data=    AcessDB::selectFromDataBase("SELECT    *    FROM
user_options WHERE user_id=".$user[0]->user_id);
```

```
            if(is_array($user) && sizeof($user)>0)
                    {echo "&send_pc=".$user_data[0]->send_pc."&".
                    "send_pda=".$user_data[0]->send_pda."&".
                    "send_itv=".$user_data[0]->send_itv."&".

"send_telemovel=".$user_data[0]->send_telemovel."&".
                     "aviso_sms=".$user_data[0]->aviso_sms."&".
                     "aviso_email=".$user_data[0]->aviso_email;
                    }
            }
            else
            {
                    echo "status=ERROR";
            }


    }
    elseif($_POST['action']=="save_user")
    {
            $save=array();
            $valores=array();

            $valores['user_name']=$_POST['nome'];
            $valores['user_sex']=$_POST['sexo'];
            $valores['user_nascimento']=$_POST['nascimento'];
            $valores['user_habilitacoes']=$_POST['habilitacoes'];
            $valores['user_telemovel']=$_POST['telemovel'];
            $valores['user_email']=$_POST['email'];
            $valores['user_pin']=(string)$_POST['pin'];


            $sql=AcessDB::insertToDataBase("user",$valores,TRUE);

            array_push($save,$sql);

            $valores=array();

            //options
            $valores['user_id']=":SQL=LAST_INSERT_ID();:";

    $sql=AcessDB::insertToDataBase("user_options",$valores,TRUE);

            array_push($save,$sql);



            $ret=AcessDB::makeTransactions($save);

            if($ret===TRUE)
                    echo "SAVED";
            else
                    echo $ret;
    }


 ?>
```

Annex O4. Main File: Return Information from the Server

```
//Stage Prop
stage.displayState=StageDisplayState.FULL_SCREEN;
stage.scaleMode=StageScaleMode.EXACT_FIT;

var palavras:PalavraChaveStore;
var palavra_activa:PalavraChave;
var active_movie:Filme;
var filmes_arr:Array=new Array();
var itvon:Boolean = true;

//TECLAS
var BTN_MENU:int = 32;
var BTN_OK:int = 16;
var BTN_PLAY_PAUSE:int = 54;
var BTN_VOLTAR:int = 53;
var BTN_SAIR:int = 52;
var BTN_1:int = 49;
var BTN_2:int = 50;
var BTN_3:int = 51;
var BTN_VERMELHO:int = 55;
var BTN_VERDE:int = 56;
var BTN_AMARELO:int = 57;
var BTN_AZUL:int = 48;

var BTN_UP:int = 38;
var BTN_DN:int = 40;
var BTN_LE:int = 37;
var BTN_RI:int = 39;

var licao_criada:Boolean=false;

//Defenições
var server:String;
var send_mail:Boolean;
var debug:Boolean;

//Initial
Mouse.hide();
var configxml:URLLoader = new  URLLoader();
configxml.addEventListener(Event.COMPLETE, configxmlXML);
configxml.addEventListener(IOErrorEvent.IO_ERROR, errorLoad);
configxml.load(new URLRequest("config.xml"));

function start_movie(filme:Filme)
{
    palavras=null;
    palavra_activa=null;
    palavras=new PalavraChaveStore();
    active_movie = filme;
/////////////////////////
    mov_cont.my_FLVPlybk.seekSeconds(filme.start_movie_time);
    mov_cont.load_mov(filme);
    pause_movie();

    mov_cont.sub_cont.subt.text="";
    var loader:URLLoader = new  URLLoader();
    loader.addEventListener(Event.COMPLETE, loadXML);
```

```
    loader.addEventListener(IOErrorEvent.IO_ERROR, errorLoad);
    var targ:String = "loadsubs.php?movie=";
    targ+=filme.src;
    var url_request=new URLRequest(server+targ);
    loader.load(url_request);
}

function set_menu_active(activo:Topico_Menu)
{
    SelectBoxBase.activeBox=activo;
}

function set_movie_full()
{
    this.mov_cont.x=0;
    this.mov_cont.y=0;
    this.mov_cont.width=stage.stageWidth;
    this.mov_cont.height=stage.stageHeight;
    this.mov_cont.my_FLVPlybk.width = stage.stageWidth;
    this.mov_cont.my_FLVPlybk.height = stage.stageHeight;
    this.setChildIndex(this.mov_cont,0);
}

function configxmlXML(e:Event):void
{
    var xml:XML;
    var i:int;
    var valuexml:String;
    var url_request:URLRequest=null;
    xml = new XML(e.target.data);
    xml.ignoreWhitespace=true;
    server=String(xml['server']);
    valuexml=String(xml['sendmail']);
    valuexml=valuexml.toLowerCase();
    if(valuexml=="true")
          send_mail=true;
    else
          send_mail=false;
    valuexml=String(xml['debug']);
    valuexml=valuexml.toLowerCase();
    if(valuexml=="true")
          debug=true;
    else
          debug=false;

/////TECLAS
     BTN_MENU=int(xml['BTN_MENU']);
     BTN_OK=int(xml['BTN_OK']);
     BTN_PLAY_PAUSE=int(xml['BTN_PLAY_PAUSE']);
     BTN_VOLTAR=int(xml['BTN_VOLTAR']);
     BTN_SAIR=int(xml['BTN_SAIR']);
     BTN_1=int(xml['BTN_1']);
     BTN_2=int(xml['BTN_2']);
     BTN_3=int(xml['BTN_3']);
     BTN_VERMELHO=int(xml['BTN_VERMELHO']);
     BTN_VERDE=int(xml['BTN_VERDE']);
     BTN_AMARELO=int(xml['BTN_AMARELO']);
     BTN_AZUL=int(xml['BTN_AZUL']);
     BTN_UP=int(xml['BTN_UP']);
     BTN_DN=int(xml['BTN_DN']);
     BTN_LE=int(xml['BTN_LE']);
```

```
        BTN_RI=int(xml['BTN_RI']);
        SelectBoxBase.BTN_UP=BTN_UP;
        SelectBoxBase.BTN_DN=BTN_DN;
        SelectBoxBase.BTN_LE=BTN_LE;
        SelectBoxBase.BTN_RI=BTN_RI;

   ////
       var userDataVars:URLVariables;

   //  Carrega Filmes
       var load_movies:URLLoader = new  URLLoader();
       load_movies.addEventListener(Event.COMPLETE, loadMovies);
       load_movies.addEventListener(IOErrorEvent.IO_ERROR, errorLoad);
       url_request=new URLRequest(server+"loadmov.php");
       load_movies.load(url_request);
   }

   function loadMovies(e:Event):void
   {
       var xml:XML;
       var filmes_xml:XMLList;
       var i:int;
       var filme_id:int;
       var filme_nome:String;
       var filme_target:String;
       var filme_descricao:String;
       var filme_webc:int;
       var filme_webc_bool:Boolean;

       var data_gravado:String;
       var data_criado:String;
       var data_modificado:String;
       var start_movie_time:int;
       var filme:Filme;
       xml = new XML(e.target.data);
       xml.ignoreWhitespace=true;
       filmes_xml=xml.children();
       for(i=0; i<filmes_xml.length()-1; i++)
       {
             filme_id=int(filmes_xml[i].attribute("id"));
             filme_nome=String(filmes_xml[i].attribute("nome"));
             filme_target=String(filmes_xml[i].attribute("target"));

       filme_descricao=String(filmes_xml[i].attribute("descricao"));
             filme_webc=int(filmes_xml[i].attribute("webc"));

       data_gravado=String(filmes_xml[i].attribute("data_gravado"));

       data_criado=String(filmes_xml[i].attribute("data_criado"));

       data_modificado=String(filmes_xml[i].attribute("data_modificado"
));
             start_movie_time                                          =
int(filmes_xml[i].attribute("start_movie_time"));
             if(filme_webc==1)
                   filme_webc_bool = true;
             else
                   filme_webc_bool = false;
             filme = new Filme(filme_nome,filme_target,filme_descricao,
filme_webc_bool, filme_id);
             filme.data_gravado = data_gravado;
```

```
        filme.data_criado = data_criado;
        filme.data_modificado = data_modificado;
        filme.start_movie_time = start_movie_time;
        filmes_arr.push(filme);
    }

    start_movie(filmes_arr[0]);
}

function errorLoad(e:Event):void
{
    var iTVOffline:ServerOffline=new ServerOffline;
    this.addChild(iTVOffline);
}

function loadXML(e:Event):void
{
    var palavra_nova:PalavraChave;
    var tempo_in:PalavraChaveTimeStamp;
    var tempo_out:PalavraChaveTimeStamp;
    var xml:XML;
    var legendas_xml:XMLList;
    var legenda_t_in:XMLList;
    var legenda_t_out:XMLList;
    var legenda_texto:XMLList;
    var legenda_textos:XMLList;

    var palavra_id:int;
    var palavra_nome:String;
    var legenda_i_h:Number;
    var legenda_i_m:Number;
    var legenda_i_s:Number;
    var legenda_o_h:Number;
    var legenda_o_m:Number;
    var legenda_o_s:Number;

    var descricao:String;
    var espacos:int;
    var texto_legenda:String;
    var i,j,s:int;
    xml = new XML(e.target.data);
    xml.ignoreWhitespace=true;
    legendas_xml=xml.children();
    for(i=0; i<legendas_xml.length()-1; i++)
    {
        palavra_id=int(legendas_xml[i].palavra.attribute("id"));

    palavra_nome=String(legendas_xml[i].palavra.attribute("nome"));


    legenda_i_h=int(legendas_xml[i].time_start.attribute("h"));

    legenda_i_m=int(legendas_xml[i].time_start.attribute("m"));

    legenda_i_s=int(legendas_xml[i].time_start.attribute("s"));

        legenda_o_h=int(legendas_xml[i].time_end.attribute("h"));
        legenda_o_m=int(legendas_xml[i].time_end.attribute("m"));
        legenda_o_s=int(legendas_xml[i].time_end.attribute("s"));

        tempo_in=new PalavraChaveTimeStamp(legenda_i_h,
```

```
legenda_i_m,

legenda_i_s,
                                                                    0);

            tempo_out=new PalavraChaveTimeStamp(legenda_o_h,

legenda_o_m,

legenda_o_s,
                                                                     0);

            descricao = legendas_xml[i].child('descricao');

            legenda_textos=legendas_xml[i].child('textos');
            legenda_texto=legenda_textos.child('texto');

            texto_legenda = '';
            if(legenda_texto.length()>0)
            {
                  espacos = 3 - legenda_texto.length() - 1;

                  for(s=0;s<=espacos;s++)
                        texto_legenda+="<br />";

                  for(j=0; j<legenda_texto.length(); j++)
                  {
                        if(j > 0)
                              texto_legenda+="<br />";

                        texto_legenda+=legenda_texto[j];
                  }
            }
            else
                  continue;

            if(palavra_nome!='')
                  trace(i);
                  palavra_nova=new
PalavraChave(palavra_nome,palavra_id);
            palavra_nova.descricao = descricao;

      palavras.addPalavra(palavra_nova,texto_legenda,tempo_in,tempo_ou
t);
      }

      play_movie();
      iTVMenu1=new Menu1;
      this.addChild(iTVMenu1);
   }

   //help functions
   function pause_movie()
   {
      this.mov_cont.my_FLVPlybk.pause();
   }

   function play_movie()
   {
      //this.mov_cont.my_FLVPlybk.play();
```

```
    }

    function replace(org:String, fnd:String, rpl:String):String
    {
        return org.split(fnd).join(rpl);
    }

    function check_caller(caller:MovieClip,e:Event)
    {
        var target:MovieClip;
        var active_box:SelectBoxBase;
        if(e.target == stage)
        {
              active_box = SelectBoxBase.activeBox;

              if(active_box==null)
                    return true;

              target                                                    =
MovieClip(caller.getChildByName(active_box.name));
        }
        else
        {
              trace('badum no check');
        }

        if(target==null)
              return false;
        else
              return true;
    }

    var iTVLogin:Login;
    var iTVMenu1:Menu1;
    var iTVMenu2:Menu2;
    var iTVMenu3:Menu3;
    var iTVLogged:Logged;
    var iTVMenu_Cria2:Menu_Cria2;
    var iTVMenu_Pesquisa:Menu_Pesquisa;
    var iTVMenu_Pesquisa2:Menu_Pesquisa2;
    var iTVMenu_Pesquisa3:Menu_Pesquisa3;
    var iTVMenu_Pesquisa4:Menu_Pesquisa4;
```

Annex O5. Managing Subtitles

```
var BASE:MovieClip;
BASE= MovieClip(this.parent);

my_FLVPlybk.fullScreenTakeOver=false;
my_FLVPlybk.play();
BASE.set_movie_full();

stage.addEventListener(Event.ENTER_FRAME,EnterFrameStage);
stage.addEventListener(KeyboardEvent.KEY_UP, keyHandlerStage);

sub_cont.subt.htmlText='';

function load_mov(filme:Filme)
{
    this.my_FLVPlybk.source = 'filmes/'+filme.src;
    BASE.active_movie=filme;
}

function keyHandlerStage(event:KeyboardEvent):void{

    if(event.ctrlKey==false)
          return;

    switch(event.keyCode)
     {
           case BASE.BTN_PLAY_PAUSE:
                if(this.my_FLVPlybk.playing == true)
                      this.my_FLVPlybk.pause();
                else
                      this.my_FLVPlybk.play();
           break;
     }
}

function EnterFrameStage(event:Event):void {

    var minutes:Number = 0;
    var seconds:Number = 0;
    var totalMinutes:Number = 0;
    var totalSeconds:Number = 0;
    var barStatActive:Boolean = false;
    var legenda:String;
    var endtime:PalavraChaveTimeStamp;

    var time:PalavraChaveTimeStamp=null;

    if(BASE.palavras==null)
          return;

    totalMinutes = Math.floor(this.my_FLVPlybk.totalTime / 60);
    totalSeconds = Math.floor(this.my_FLVPlybk.totalTime) % 60;
    minutes = Math.floor(this.my_FLVPlybk.playheadTime / 60);
    seconds = Math.floor(this.my_FLVPlybk.playheadTime) % 60;

    //remove palavra
    endtime = BASE.palavras.nextEndTime;
```

```
if(endtime!=null)
{
      if(endtime.hora<=0 &&
         endtime.minuto<=minutes &&
         endtime.segundo<= ( seconds - 1) )
       {
             sub_cont.subt.htmlText='';
       }
}

//adiciona nova palavra
if(BASE.palavras.palavraExists(0,minutes,seconds)==true)
{

BASE.palavra_activa=BASE.palavras.getPalavra(0,minutes,seconds);
      legenda = BASE.palavras.getLegenda(0,minutes,seconds);

      if(legenda != null)
            sub_cont.add_legenda(legenda,BASE.palavra_activa);
}
```

Annex O6. Example from a GPS Return File

```
var geocoder;
var map;
var infowindow = new google.maps.InfoWindow();
var marker;
function initialize() {
  geocoder = new google.maps.Geocoder();
  var latlng = new google.maps.LatLng(40.730885,-73.997383);
  var mapOptions = {
    zoom: 8,
    center: latlng,
    mapTypeId: 'roadmap'
  }
  map = new google.maps.Map(document.getElementById('map-canvas'),
mapOptions);
}

function codeLatLng() {
  var input = document.getElementById('latlng').value;
  var latlngStr = input.split(',', 2);
  var lat = parseFloat(latlngStr[0]);
  var lng = parseFloat(latlngStr[1]);
  var latlng = new google.maps.LatLng(lat, lng);
  geocoder.geocode({'latLng': latlng}, function(results, status) {
    if (status == google.maps.GeocoderStatus.OK) {
      if (results[1]) {
        map.setZoom(11);
        marker = new google.maps.Marker({
            position: latlng,
            map: map
        });
        infowindow.setContent(results[1].formatted_address);
        infowindow.open(map, marker);
      } else {
        alert('No results found');
      }
    } else {
      alert('Geocoder failed due to: ' + status);
    }
  });
}

google.maps.event.addDomListener(window, 'load', initialize);
```