

CYCLE OF PDCA T-LEARNING MODEL AND ITS APPLICATION ON INTERACTIVE DIGITAL TV

CICLO DEL MODELO PHVA T-LEARNING Y SU APLICACIÓN EN LA TELEVISIÓN DIGITAL INTERACTIVA

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ABSTRACT: Digital television (DTV) provides pedagogical and technological advantages to education. DTV is presented as a novelty for the audience and involves the convergence of education, telecommunications, and internet in a unique environment. This technology will allow for the development of interactive educational platforms known as t-learning platforms. Currently, there are relatively few models which describe the processes involved in t-learning. This article presents a cyclic model, which takes into account the feedback of the process and other requirements. It also presents the theoretical framework associated with t-learning. It describes the PDCA t-learning proposed model (PDCA is plan, do, check, and act) that has been implemented in a prototype of a module (wireless networking fundamentals) on the area of telecommunications. This application was tested in a digital terrestrial television (DTTV OR DTT) laboratory.

KEYWORDS: digital TV, t-learning, PDCA t-learning model, DVB, ICT in education, interactivity and adaptation.

RESUMEN: La televisión digital (TD) brinda grandes ventajas pedagógicas y tecnológicas a la educación. La TD se presenta como una novedad para los telespectadores y supone la convergencia de los sectores educativo, telecomunicaciones e internet, en un mismo medio. Esta tecnología permitirá el desarrollo de plataformas educativas interactivas conocidas como t-learning. En la actualidad, son escasos los modelos que describen el proceso de t-learning. En este artículo se presenta un modelo cíclico, que toma en cuenta la retroalimentación del proceso y otros requisitos. Presenta también el marco teórico asociado a t-learning. Describe el modelo PHVA (Planear, Hacer, Verificar, Actuar) propuesto, el cual ha sido implementado en un prototipo de un módulo (Fundamentos de redes WiFi) en el área de las telecomunicaciones. Este aplicativo se probó en un laboratorio de televisión digital terrestre (TDT)

PALABRAS CLAVE: televisión digital, t-learning, modelo PHVA t-learning, DVB, TIC en educación, interactividad y adaptación.

1. INTRODUCTION

Digital TV (DTV) is considered to be the convergence of television and computing technologies, bringing together three typical features such as interactivity (which means that the user can control the activities), customization (which is adapting the interactive contents for each user profile), and digitalization (the technological advances that allow the highest sound and image quality) [1]. DTV is made operational either by cable, satellite, microwave, terrestrial broadcast; or by ADSL or IP (IPTV and WebTV) trends. Also, several applications can be developed with DTV, such as t-administration, t-commerce, t-programming, t-learning, t-entertainment, t-advertising, t-information, t-employment, t-health, and interactive applications in private TV networks. In this article we will emphasize *t-learning*.

In Colombia, the Colombian National Television Commission (CNTV, Spanish stands for Comisión Nacional de Televisión) began to implement DTV and to project itself with DTV, based on the European standard (digital video broadcasting, DVB) [2], known as DVB-T for terrestrial type, DVB-H for mobile devices, DVB-S for satellite, and DVB-C for cable transmissions. The choice of DVB-T was announced on August 28, 2008 and reaffirmed in the December 2010 Agreement by the CNTV [3]. It also defined the use of compression format MPEG-4. Under the standard DVB, it was made standard that the *middleware* (interface between applications and operating system) is the *Multimedia Home Platform* (MHP) [4], which is used in digital receivers to allow the execution of interactive applications. Multimedia home platform applications are of two types: *Hyper*

Text Markup Language (DVB-HTML) and DVB-Java. Java programming is the most widely used.

The motivation behind this paper is to initiate research and development in learning applications for DTV in Colombia. This is due to the limited number of model researches existing, allowing to understand what it is needed for their implementation. Among the researches related to *t-learning* there is the ELU project [18,29] founded by the European Community to develop educational resources (tools for creating, prototypes, and virtual teacher systems) through interactive DTV, but it does not present a model for developing *t-learning*. The VEMiTV project [7]- research conducted in Portugal, focused on testing the potential of DTV as an educational tool- assesses the usability and cognitive response of the students. This research lead to the creation of the 'Panda' application, which is based on the Microsoft TV platform but it does not present a model either. Companies such as the BBC [11] have developed several educational applications for children such as CBeebies, but they do not detail models of implementation either. In [1], a *framework* is proposed for *t-learning* courses, which is divided into two parts: the production and the client. That research is not clear about the development of a prototype and does not show results of the *framework's* use. In [30] there is also a *framework* for collaborative educational services; it creates *t-learning* contents with its own tools, it does not take customization into account and does not present an explicit model. In [16], an alternative framework for DTV applications is presented, but it does not deal with general purposes on learning-oriented contents in depth. In [31], a service model is manifested, but it has limitations in the return channel and possibilities of interaction. It is only for DVB-J and is based on the idea that *t-learning* is just *edutainment*. In [13], a conceptual framework for customization is shown, and some simulations on PC are performed; however, there is no general model. The EDiTV project [33], implemented in Latin America, focuses on distance virtual education courses using IPTV. The latter project is lined up with agro-industrial topics and participatory action research (PAR). It does not show evidence on TV and there is no explicit model. Others like [32] and TV Escola [12] in Brazil explore educational content development, but it is based on the Japanese standard, which is different from the Colombian one. In [15], a requirement model approach is presented, that, in addition to be linear, focuses on DVB-HTML. In this model, a description of the elements involved is missing, and there is no practical example of its use.

In this paper a cyclic model is presented, which takes into account the feedback of the process and other requirements. An example of its use is also presented. It also serves as the basis for any other application or subject, taking into account the aspects considered in the model stages. The rest of the paper is organized as follows: In Chapter two the theoretical framework associated with *t-learning* is presented. In Chapter three, the PDCA *t-learning* proposed model is described. In Chapter four the results of implementation of the model and the application on *Wi-fi* are shown. Afterwards, recommendations are presented. Then conclusions are drawn and, finally, the bibliography is listed.

2. T-LEARNING

T-learning are teaching and learning processes based on the DTV. They are the convergence of TV technologies with telecommunications and systems (informatics), and are in accordance with the education and audiovisual sectors, among others.

Other definitions of *t-learning* are: interactive learning via television, or interactive access to video-rich educational contents mainly for home use, through a TV [5]. It is a subset of *e-learning*, the latter referring to any form of learning through a digital electronic device connected [6]. Thus, [19] defines *e-learning* as a generic term for the use of various tools and resources such as the Internet, intranets, CD-ROM, multimedia presentations, among others. *T-learning* is the convergence of DTV and *e-learning* technologies [7], [8]. It is the convergence of television and computer technologies (and more specifically, the Internet) [9]. Figure 1 details that convergence.

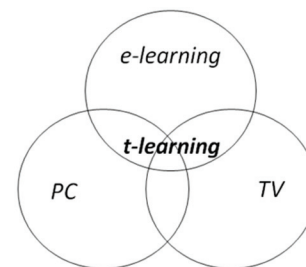


Figure 1. Convergence PC, TV and e-learning

For [15], *t-learning* is the convergence of different media (mobile technologies and Internet protocols)

and *e-learning*. Importance is given to the term *learning* to indicate the active role of the student, based on the constructivist approach, where the student is responsible for his/her own learning, as it is also mentioned by [19].

It is important to note that IDTV has its impact if there is an interaction channel (return channel), and its presence or absence affects services and applications established for users (customization, requests and communication, among others). Among *t-learning* applications are: formal and informal learning courses, support on formal learning courses of educational institutions, specialized training courses (interested business and individuals), support on home care, continuing education programs in several disciplines, personalized courses, social and support training, training for immigrants (languages or others), and training programs for people in remote areas. The propitious scenarios for *t-learning* are designed according to the student's willingness for education through television [1]:

Edu-tainment -education + entertainment- allows to watch TV while offering a course related to the TV program, or to follow a formal education course that has been improved to make it more effective and entertaining (such as games, movies or game shows). In this experience, educational contents are more relevant [13].

Entertain-sion -entertainment + television- provides educational contents associated with the program the viewer is watching. Those contents allow the viewer to go into the topic in depth; for instance, learning a language by watching a soccer game [14].

3. PDCA T-LEARNING MODEL

The model is composed of four main stages, namely: plan, do, check, and act (PDCA). Plan, to see what is already done, what is to be achieved, and the specifications and assignments to be defined. Do, to begin the construction of the learning environment and everything previously defined. Check, to verify the application's deployment; and Act, to take into account the feedback perceived from the educational project and thus, to redefine future processes. Figure 2 illustrates the cycle plan-do-check-act (PDCA). Figure 3 details the proposed PDCA *t-learning* model.

3.1. Plan stage

There is a first initial state phase characterized by a knowledge society, by its population (students), teachers, and the available technologies, among other features of the environment. After this, the requirement model based on [15], [17] is considered, which describes the necessary features and functions (see Table 1). These requirements are part of the production of pre-content phase. The support team is defined to support the *t-learning* project. Besides, the subjects and their demarcations, the preliminary sketch and the target public are defined here.



Figure 2. PDCA *t-learning* model cycle

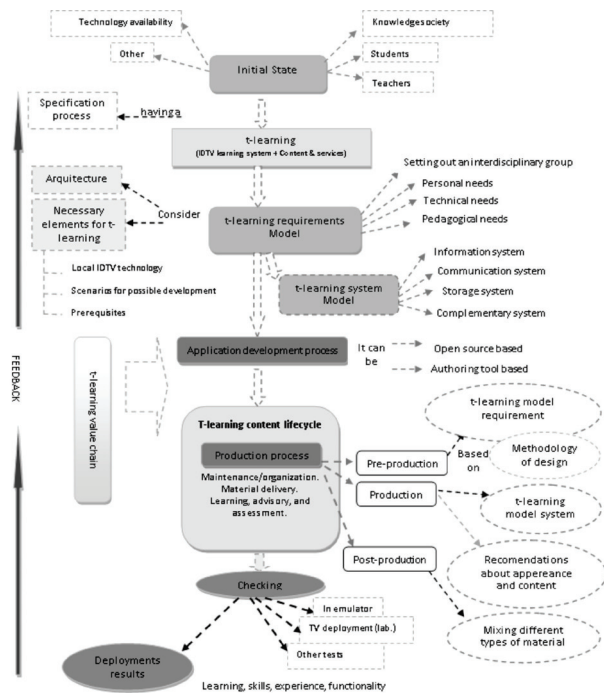


Figure 3. Teaching model based on DTV, *t-learning*

Table 1. *T-learning* requirement model

Technical: transmission of the learning environment, interaction and communication, security, accessibility, system control, and usability.
Pedagogical: contents, way of assessment, <i>t-learning's</i> role, interactivity, if there is construction of knowledge, learning process, customization, if it is connected to a TV program, etc.
Personal: the type and purpose of learning, accessibility, motivation, expectations, and special needs.
Team: support staff such as pedagogue, consultant, programmer, teacher, visual designer, and engineer.

The necessary subsystems (of information to be transmitted, of communication if there is a return channel, and of storage, or any other specific item) to achieve the purpose of the service are planned; and alternative solutions for their construction are given.

3.2. Do stage

This stage constitutes the first phase of the construction process of the application, its design (final sketch of contents, navigation, video, game, etc.), and encoding. In this stage, it is also defined whether the application is done in open source tools or with commercial software programs known as *authoring tools*, such as [25] and [27]. To develop the *plugins* some complementary programs are necessary [20].

Within the life cycle of *t-learning* contents is the content production phase. It is divided into the sub-phases of pre-production, production (subsystems), and post-production (all the elements of the application and videos are combined). Also, the general recommendations for the contents and deployment are taken into account, considering the TV as a means [15], [21], [22], [23], [10]. Special attention must be taken with aspects such as font size, backgrounds and colors, navigation, appropriate use of remote control, usability, interface, cultural and educational aspects, aids, images, interaction options, among others.

On the other hand, technologies, architectures and infrastructures, equipment, servers, etc. must be considered, from the *set-top-boxes* (STB) for receiving and decoding digital signals, to the analog or digital TV set, through the MPEG 2/4 encoders, modulators, special boards, multiplexer, and return channel technology, among others. A *playout* server will be needed (it integrates coded elements, the generation of the object carousel, and the generation of programs, services and information of applications). To achieve a true broadcast

environment, separate servers are needed, for instance, for the programming and video guides, for sending applications, for the interactive control servers, for authentication and profile, etc. It may also be necessary to have a more specialized content server for a learning management system (LMS) [39], or a content management system (CMS). There are several commercial suppliers with laboratory equipment and DTV broadcast stations such as [24], [25]. The *t-learning* value chain is extensive and involves several factors such as programmers, content creators, technology, among others.

3.3. Check Stage

Considering the life cycle of *t-learning* contents, in this stage the delivery of learning materials is guaranteed, with the transmission of the service and the applications. Here, the first phase is visual display, verifying the signal deployment and reception on the TV, or through an emulator on the computer such as [26], [28]. In the second phase more tests of its running can be done in the experiments laboratory or at a real TV broadcast center. Appropriate adjustments will be made if necessary. After the solution or proposal set out, there is a result of the project implementation, and a learning result and possible skills for the student. Here, the student is receiving and interacting with information on the TV.

3.4. Act stage

The last phase, the feedback phase, is about reviewing the whole process and the final results, evaluating and / or refining the process, and monitoring the result again. This allows involving a continuous improvement process, collecting the experiences and observations from the student or expert, continuing the research, improving the design or functionality, and adding other elements such as a virtual tutor, games, customization, among others.

4. PDCA MODEL APPLICATION RESULTS

For the development of the prototype application some aspects based on the proposed PDCA *t-learning* model were taken into account. For test effects, only one cycle will be put into practice.

4.1. Plan stage

- Based on the DVB standard, and MHP.
- It is a one-course module.

- The goal is a prototype of a *t-learning* application on *Wi-Fi* wireless networks fundamentals.
- The target group is students of Technology and Engineering with a major in telecommunications.
- The pre-production phase starts by defining the requirements according to the proposed model. Those are:
- Interdisciplinary support, teacher, consultant and programming engineer.
- Items taken as reference for technical needs (see Table 2).
- Items taken as reference for personal or target group's needs (see Table 3).
- Items taken as benchmark for the final service (see Table 4).

4.2. Do stage

- A thematic presentation sketch in MS-Power Point is made.
- The development of the interface starts. An initial programming scenario is taken into account by using open source libraries, Java classes, and the OpenMhp emulator for simulation [34-38].
- Another scenario is to illustrate the usefulness of the authoring tool iTV suite [25].

Table 2. Points of reference for technical needs

<i>Dimension</i>	<i>Description</i>
Transmission	-The role of iTV technology in broadcasting (different technologies). -Availability in the service (impulse service). <i>Time-Shifting</i> (recording programs to watch them later).
Interaction / communication	One-way interaction (contents) Two-way-interaction (authentication)
Security	-Data Integrity -Authentication
Accessibility	-Accessibility to appropriate technology -Accessibility of the applications Accessibility to open standards -Accessibility to widely accepted and used standards.
Devices	Input Elements simulated in PC (remote control), and remote control Output Simulation environment in PC, and TV + STB.

<i>Dimension</i>	<i>Description</i>
Usability	Within the learning environment -Relevant information presented -Support images -Clearly marked exits.
	Environment interaction during student-learning process. -Learning skill. -Devices working together without any problem.
	Student Experience -Easiness of learning -Usability -Valuability

- Subsystems of information (contents), communication (return channel to authenticate), and storage (users database) are complemented.

Table 3. Points of reference for personal needs

<i>Dimension</i>	<i>Description</i>
Kind of Learning Learning goal	-Informal learning -Learning the fundamentals of wireless networks (<i>Wifi</i>).
Accessibility	- Personal (local) -Technical (TV, STB, remote control, if there is return channel, and PC with the simulation environment).
Motivation, expectation	- Motivation to use iTV. - Expectation concerning the devices. -Previous experience with web-based education. - Finding active attitude.
Special Needs	- (None), students are considered to be in good physical and mental conditions.

Table 4. Points of reference for pedagogical needs

<i>Dimension</i>	<i>Description</i>
Role of <i>t-learning</i>	Additional
Contents	Guide Learning materials (text, images)
Interaction	Student - learning material
Evaluation	Self-Assessment
Construction of knowledge	- Yes / No.
Learning Process	- Yes / No.
Personalized Learning	No
Connected to a TV program	No

4.2.1. Description of the simulation system

It is based on the Eclipse development environment for the respective encoding. A web server allowing to store course and user navigation data is set. The following components are needed: Apache Tomcat (6.0), Java (Jre 1.5.0.22), and MySQL. Wampserver program is recommended (Apache server, MySQL and PHP). By setting the packages classes (Java), and libraries, the following are defined for simulation: a content server (it stores information about the “course” progress and repository function); an authentication server (login and user registration); and a return channel (for data submission process). A ‘client’ is defined, which is the part that runs on the simulator (emulator) or for a STB. The client makes requests to log in and access the resources of the “course” stored in the contents server by calling the web services.

Figure 4 describes the architecture for PC simulation. In this case, both the *web services* server software and the database engine will be on the same simulation computer (PC with the software needed).

Figure 5 describes the architecture with equipment for deployment testing of the TV in a DTT environment. For this experience, they were also used in hardware: (Playout server PC100 Icareus, also called carousel server; TV LG 42”, STB i-CAN 3810T MHP 1.1 with support for the return channel via Ethernet); and in software: (configuration software for Playout server PC100, Eclipse-Osmosys SDK, Osmosys Navigator).

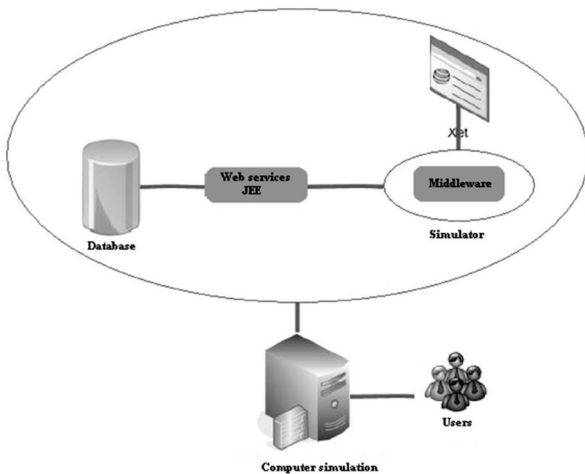


Figure 4. PC Architecture of simulated prototype

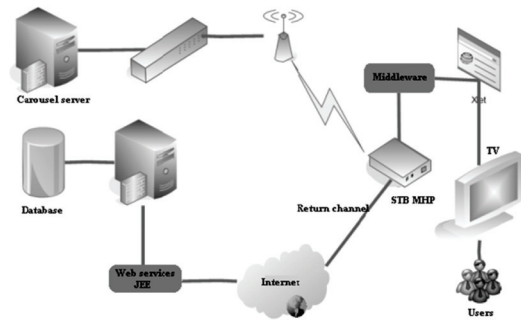


Figure 5. Architecture for deployment test in TV

4.3. Do stage of PDCA model

In this section, the tests performed and a *checklist* to assess the application comprehensively are presented. A simulation environment based on *PC* and at a test laboratory is defined. Figure 6 shows the operation of the simulated application on a *PC*.



Figure 6. Prototype interface and PC emulator

The user can interact with the navigation buttons (arrows, *OK*, yellow and red buttons on the remote control simulator), and choose the theme. At the end, the *quiz* option appears (self-assessment). Figure 7 shows the deployment test on TV, using an interactivity laboratory.



Figure 7. Deployment tests on TV.

Figures 8 and 9 illustrate the result of using authoring tools (iTV suite) and Icareus commercial equipment, in an interactivity laboratory.

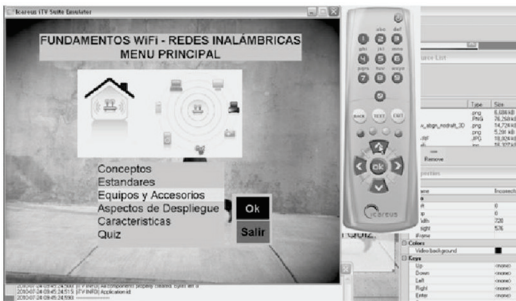


Figure 8. Test in the Icareus iTVsuite emulator

Checklist method is used to evaluate the performance and perception of the t-learning application. It consists of questions about the characteristics of the application and is based on usability issues. Twelve people were invited to participate in the tests. The application provides basic fundamentals of wireless networks (Wi-Fi), and also assesses the learning achieved. After interacting with the application, they received a form with the checklist, in which each item is assessed with “yes”, “partial” or “no” options, allowing inspection of the technical, pedagogical and personal elements. Figure 10 illustrates an example of a result of the checklist applied.

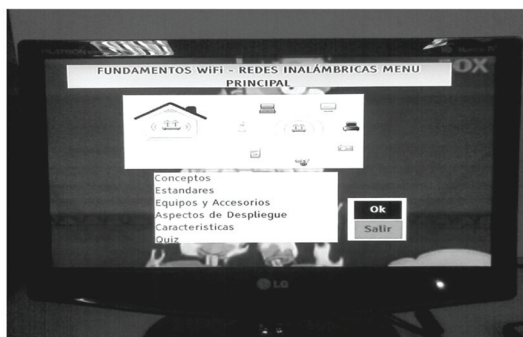


Figure 9. Application test developed with iTVsuite on TV.

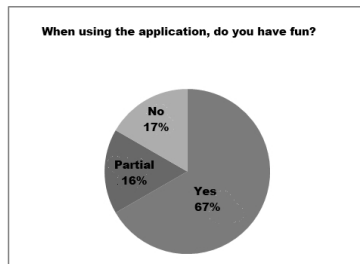


Figure 10. Example of results of the application checklist

The results of the evaluation and testing indicate that the operation of the application was verified under DTV.

4.4. Act stage

- Adapting it to other contents or courses, such as optical communications, languages, mathematics, among others.
- Extending the theme or adding other modules.
- Evaluating the application in a real one-semester course in an institution.
- Improving the aesthetics of the interface and images, adding more interactivity and customization.
- Improving student-teacher interaction.
- Expanding student support.
- Involving audiovisual elements.
- Debugging the results of the *quiz*.
- Testing it in a real environment of TV broadcast.
- Expanding developing experience.
- Seeing the option of games or animations.
- More tests to see how efficiently the application works with more users and in different scenarios (e.g. by cable, satellite, IPTV, other STB other, and other forms of return channel).
- Checking the learning achieved.
- Involving other people in the interdisciplinary group (e.g., a pedagogue).
- Adding management.
- Accessibility to infrastructure and editing tools.

5. RECOMMENDATIONS

These are some recommendations for this research:

- Consider the participation of an interdisciplinary group.
- Understand and involve all the segments of the DTV value chain and *t-learning*.
- Monitor the standards of DVB and the evolution of the technology inherent to TV.
- The return channel has to be applied through

technologies supporting *IP* such as *Ethernet* or *xDSL* technologies (*Digital Subscriber Line*). Besides, it has to be supported by the STB. For more remote areas, availability for the return channel can be guaranteed with GPRS cellular networks, WiMax, or another microwave system; or with terrestrial return according to the DVB RCT standard.

- The do stage, when the application is designed and developed requires time, and this must be considered.
- DTV lab equipment and software must be bought.
- A broad social pedagogy on the use and production of the new means is required.
- To ensure the production of true educational programs within the DTV, it is necessary for the education sector to work jointly with the media and related companies.
- To properly link the DTV with the learning processes, some studies are required in order to provide guidelines for research and practice in this field.
- Universities should be attentive because new professionals are needed to implement, use and create contents (multi-product development, including audio, video and data).
- As future work, it is recommended to implement several cycles of the presented model, considering in the Check and the Act stages the aspects in the results that have to be improved. This will allow to have a better application to achieve its result: learning. The model could even be made into a real deployment product.

6. CONCLUSIONS

In this article, a PDCA model of *t-learning* is presented. It includes different stages for the development of an educational project based on DTV; and indirectly provides information about the basis and elements involved. The model's application and the results of *t-learning* application development on a module of Fundamentals of *Wi-Fi* wireless networking are shown here, as well as the evaluation through laboratory tests on both *PC* emulator and deployment in DTT scenario. This model can be implemented in similar projects,

taking into account each stage considered, such as how to define subjects, requirements (plan stage), open source application or authoring tools (do stage), checking application running and assessment (check stage), and improvements (act stage). Besides, although the model is defined for the domain of *t-learning*, it is the basis for various applications in DTV. This proposal is developed under open standards such as DVB and MHP. It has been proved that it is possible to have an experimental laboratory from the open source development and computer simulation.

As DTV is implemented, research, and training efforts should be strengthened, and projects supported on all underlying opportunities of digital technology on TV should be developed. DTV offers multiple options in the information society; among them, the convergence of electronics, telecommunication and informatics. Although the technology is the essential basis, it is necessary to provide it with contents. The expectation with the development of applications on television is higher or equal than the one with the start of *e-learning* based on *PC*. The door is open to implement it in other projects in different fields.

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REFERENCES

- [1] Bellotti, F., *t-learning* courses development and presentation framework. In: IEEE Multidisciplinary Engineering Education Magazine. Vol.3, No.3, pp.69-76. Sept. 2008.
- [2] DVB. Available online: <http://www.dvb.org/> [consulted on Aug 14, 2011].
- [3] CNTV. Cronograma. Available online: http://www.cntv.org.co/cntv_bop/tdt/contenido4.html [consulted on Aug 13, 2011].
- [4] MHP. Available online: <http://www.mhp.org/> [Consulted on Sep. 2011].
- [5] PJB Associates. A study into TV-based interactive learning to the home. UK, IST Programmer (1998-2002), May 2003.

- [6] Rey, Marta, Diaz, R., Fernández, A., educación a la carta para IDTV. Memorias V Jornadas de Ingeniería Telemática JITEL. Vigo, Spain, 133-140, Sept. 2005.
- [7] Damasio, Q., Quico, C., t-learning and interactive television edutainment: the portuguese case study. In: 2nd European Conference on Interactive Television, Brighton, United Kingdom, 2004.
- [8] Disessa, A., Changing minds: computers, learning, and literacy. MIT Press. (consulted on March 15, 2011). Available online: <http://mitpress.mit.edu/main/home/default.asp>
- [9] Miltiadis, L., Chris, L., Polyneikis, C., Athanasia, P., Interactive television and e-learning convergence: examining the potential of t-learning. ELTRUN, the eBusiness Center. Disponible <http://www.eltrun.aueb.gr> (consulted on Oct. 12, 2010).
- [10] Karyn, Y., Interaction design principles for interactive television, [Master Thesis]. Georgia Institute of Technology. USA, 2005.
- [11] BBC. CBeebies. Available online <http://www.bbc.co.uk/cbeebies/> (consulted on Sept. 30, 2010)
- [12] TV Scola. Ministério da Educação. Disponible <http://portal.mec.gov.br/tvescola/> (consulta: 25 sep. 2010).
- [13] Rey, M., Marco conceptual y arquitectura para el aprendizaje personalizado a través de Televisión Digital Interactiva [PhD Thesis]. Spain: Universidad de Vigo, 2009.
- [14] Rey, M., Entercation experiences: engaging viewers in education through TV programs. Proceedings of EuroITV, Athens, 2006.
- [15] Aarreniemi, P., Modelling and content production of distance learning concept for interactive digital television [PhD Thesis]. Helsinki: University of Technology, 2006.
- [16] Vrba, V., Cvrk, L., and Sykora, M., Framework for Digital TV Applications. Fifth ICNICONSMCL. IEEE Computer Society, Mauritius, April 2006.
- [17] Moreno, G., Modelo *t-learning* para procesos de formación en la educación superior, [Msc thesis]. Medellín: Universidad Pontificia Bolivariana, 2010.
- [18] Zajc, M., Development of interactive television t-learning course. In: Electrotechnical Conference MELECON. The 14th IEEE Mediterranean, Ajaccio, pp. 139-144, 2008.
- [19] Gómez, M., Uribe, G., Jiménez, J., Nueva perspectiva de los entornos virtuales de enseñanza y aprendizaje en ingeniería. Caso práctico: operaciones con sólidos. Medellín: Dyna, Nro. 160, 2009.
- [20] OSMOSYS. Available online <http://www.osmosys.tv/> (consulta: 7 feb. 2011).
- [21] Hansen, V. Designing for interactive television v 1.0. UK: BBC, July 2005.
- [22] Ministry of Transport and Communication. A guide for digital TV service producer. ISBN 952-201-001-4. Helsinki, Finland: Arvid publications, 2004.
- [23] FSP-UGT. Tecnoloxías de comunicación e información aplicadas á formació. Galicia: España. Federación de Servizos Públicos da Ugt de Galicia, 2009.
- [24] Tmira Solutions. Disponible <http://www.tmira.com/> (consulte don Feb. 14, 2011).
- [25] Icareus. Technologies. Available online <http://icareus.com/web/guest/home> (consulted on Feb. 7, 2011)
- [26] Xletview. Available online: <http://www.xletview.org/> (consulte don Jan. 10, 2011).
- [27] OpenTV. Available online: http://www.opentv.com/support/dev_tools.htm (consulted on Dic 15, 2010).
- [28] OpenMHP. Available online: <http://www.openmhp.org/> (consulte don Jan. 10, 2011).
- [29] ELU (Enhanced Learning Unlimited). Resources. Available online: www.elu-project.com (consulted on Sept 21, 2011).
- [30] Blanco, Y., A technological framework for TV-supported collaborative learning. In: IEEE Sixth International Symposium on Multimedia Software Engineering ISMSE'04. IEEE Computer Society Washington, DC, USA, 2004.
- [31] López, M., Bringing standard into T-learning. Proceedings of 3rd EuroITV. Aalborg, Denmark, pp. 79-86, 30 Mar - 1 April 1, 2005.
- [32] Pinto, O., An engineering educational application developed for the Brazilian digital TV system. En: 38Th ASEE/IEEE Frontiers in Education Conference. Saratoga Springs, New York, p. S2F-14-19, Oct. 2008.
- [33] EDiTV. Educación virtual basada en televisión interactiva para apoyar procesos educativos a distancia. Available online <http://www.unicauca.com>

edu.co/EDiTV/index.php?op=0> (consulta: 11 Ago. 2011).

[34] CODE4TV. Códigos. Available online: <http://www.code4tv.com/c/tutorialmhp112> (consulted on April 9, 2010).

[35] MHP Project. Códigos. Available online: <http://www.mhproject.org/index.php/mhpenlaces> (consulted on Jun 13, 2010).

[36] MHP-knowledgebase. Códigos. Disponible <http://www.mhp-knowledgebase.org/> (consulta: 9 abr. 2010).

[37] TV withoutborders. Códigos. Disponible <http://www.tvwithoutborders.com/> (consulte don April 9, 2010).

[38] Java TV. Disponible en: <https://javatv-developers.dev.java.net/> (consulte don April 9, 2010).

[39] Montenegro, C., Application of model-driven engineering (MDA) for the construction of a tool for domain-specific modeling (DSM) and the creation of modules in learning management systems (LMS) platform independent. Medellin: Dyna, N°. 169, 2011.