Teledu: Transmedia Learning Ecosystem for People at Risk of Exclusion

Carlos de Castro Lozano[1(✉)], José Miguel Ramírez Uceda[1], Beatriz Sainz de Abajo[2], Enrique García Salcines[1], Jon Arambarri Basañez[3], Joaquín Aguilar Cordón[1], Javier Cabo Salvador[1], and Francisco Alcantud Marín[4]

[1] University of Cordoba, CITEC Campus de Rabanales, 14012 Córdoba, Spain
ma1caloc@uco.es
[2] University of Valladolid, Paseo de Belén, 15, 47011 Valladolid, Spain
[3] European University of the Atlantic, Calle Isabel Torres, 21, 39011 Santander, Spain
[4] University of Valencia, Avenida de Blasco Ibáñez, 13, 46010 València, Spain

Abstract. The TELEDU tele-education ecosystem, integrated by software and hardware components, allows the use of Web resources through *Interactive Digital TV* (iDTV) without the need to be continuously connected. It works with any existing digital TV standard and is especially useful for users who do not have broadband, being a very effective solution in places where there is a digital divide. The user must have, at least, a cell phone with 3G connection and any of these three options: *Digital Terrestrial TV* (DTT), Satellite TV or Cable TV. The conception of TELEDU is based on the premise that the software will offer a friendly interaction. Based on this, an interoperable, open and scalable environment has been developed, which works with PCs, tablets, smartphones and digital TV, offering a visual interface oriented to children, the elderly and people with functional diversity and people with technophobia. The concept of *Transmedia Online Object Content* (TOOC) is introduced, so that digital contents are in different formats and people with functional diversity and people with technophobia. The concept of TOOC is introduced, so that digital contents are in different formats (paper book, e-book, post, audio, interactive video, virtual reality, serious game, webinar, etc.), on different devices and platforms, locally or in the cloud, with usable multimodal access designed for everyone, and adapting to each user, regardless of the accessibility problems they have.

Keywords: *Interactive Digital TV* (iDTV) · Hybrid IPTV · *Transmedia-Learning platform* (Tm-Learning) · *Massive Open Online Course* (MOOC) · Extended reality · Learning objects · Interactivity · Usability · Accessibility · Gamification · *Transmedia Open Object Content* (TOOC)

1 Introduction

In recent times, there has been a paradigm shift in the consumption of content, mainly by the new generations. Internet users and mobile devices have grown exponentially, as has the viewing of videos and photos on social networks. Seventy percent of the

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world's population has a cell phone with a minimum data connection. The number of households with access to television services has also increased. In 2018, the number of households watching television through one of the existing platforms exceeded 1.6 billion. In addition, forecasts point to a gradual increase in this figure, to over 1.7 billion in 2023[1].

Despite well-known and controversial initiatives by technology corporations to increase connectivity in the global South, such as Facebook's *Free Basics* [1], there are still millions of users without Internet access. This exacerbates inequalities and their integral development. It is therefore necessary to focus on reducing the digital divide in the long term [2]. This gap has a special impact on education. Not all students can access the Internet to follow the school course, nor do all those who do have access do so under equal conditions[2].

The Covid-19 pandemic has brought about major changes in schools and in the way teacher-student communication takes place. According to a study by Empantallados[3] and GAD[4], with support from the European Commission, one out of every two families has bought an electronic device for their children's online classes. The Universidad Internacional de La Rioja (UNIR) highlights a 900% worldwide growth in online training since 2000[5].

During the confinement, schools and universities broadcast their classes by videostreaming, using Zoom, Meet, etc., increasing the use of e-Learning platforms such as Moodle, and access to video MOOCs. Only families with broadband WiFi or 4G data flat rate have been able to access.

To avoid the digital divide among families who do not have broadband Internet at home and considering that television has become the most important means of communication in the house, governments and universities are called upon to propose alternatives that allow access to digital content. In this way, by encouraging the use of television, educational programs based on high quality interactive videos have been proposed.

Many countries, in order to solve the problem, have created educational TV channels to broadcast classes via DTT, cable or via satellite, aimed at families with scarcely any economic resources. Unlike those who have broadband Internet at home, these families have not been able to access an e-Learning platform and, therefore, did not work interactively and collaboratively with the rest of the students and teachers.

Moreover, thinking about users without broadband access, but who have television and a mobile device with 3G access, the TELEDU ecosystem was developed. A preliminary lecture of the work has been presented at the ninth Iberoamerican Conference on Applications and Usability of Interactive Television, jAUTI 2020. This paper elaborates

[1] https://es.statista.com/estadisticas/600298/numero-de-hogares-con-television-a-nivel-mundial/.

[2] https://www.unicef.es/educa/blog/covid-19-brecha-educativa.

[3] https://empantallados.com/.

[4] https://gad3.com/estudio-de-empantallados-y-gad3-el-impacto-de-las-pantallas-en-los-hogares-espanoles-durante-el-confinamiento-d17/.

[5] https://www.unir.net/actualidad/internacional/por-que-triunfa-el-sistema-de-educacion-universitaria-on-line-en-espana-y-colombia-replica-su-modelo/.

and shows more extensively the scope of the development and evaluation of the usability of the training platform.

2 Background

2.1 Hybrid IPTV

Unlike analog television, *Integrated Digital Television* (iDTV) allows incorporating, in addition to the audio/video signal, a data signal through which applications (software) travel to the viewers' receivers or *Set-Top-Box* (STB). These can interact with the program transmitter (the television station), as well as the alternative of broadcasting the same contents through interactive IPTV broadcasting systems.

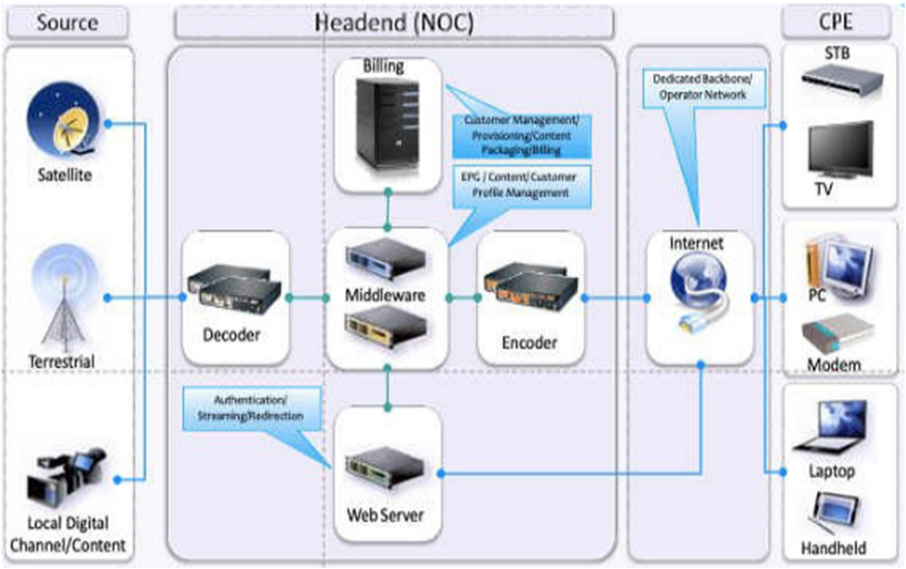

Fig. 1. IPTV system achitecture. Source: SlideShare.

Although different standards have emerged globally for the broadcasting of television, hybrid IPTV[6] (Fig. 1) is the solution to these problems of global standardization of iDTV.

The hybrid set-top box allows content from a variety of sources, including terrestrial broadcast, satellite and cable, to be combined with video delivered over the Internet via an Ethernet connection on the device.

This makes it easier for viewers to access a wider variety of content on their TVs, without the need for a separate box for each service. Hybrid IPTV set-top boxes also allow users to access a range of advanced interactive services, such as VOD/catch-up

[6] https://es.qaz.wiki/wiki/Internet_Protocol_television.

TV, as well as Internet applications, including video telephony, surveillance, gaming, shopping, e-government, etc., through a TV set.

Low-income households, because it depends on a flat monthly fee, cannot enjoy the hybrid IPTV broadband standard. However, most of these families, even the poorest, have a cell phone with 3G and free access to DTT, satellite TV or cable TV.

Hybrid Broadcast Broadband TV (HbbTV) is an initiative that seeks to harmonize IPTV broadcasting, broadband and entertainment content delivery through smart TV sets connected to set-top boxes. It can be considered a hybrid IPTV technology alternative to SmartTV technology [3, 4]. While SmartTV requires downloading different applications to access the information it offers, with HbbTV technology there is no need to download anything. Just press a button on the remote control and a menu will be automatically displayed on the TV. In June 2018, three major Spanish platforms, the publicly owned Radio y Televisión Española, S. A. (RTVE) and privately owned Atresmedia and Mediaset España joined forces to launch officially the LOVEStv service, based on HbbTV, which is completely free for users and will seek to become a new evolution of free-to-air television.

2.2 Transmedia Learning Platform and Transmedia Interactive Learning Objects

Transmedia, interactive, accessible, gamified, usable and adaptive contents, which can be easily produced by the teacher or the student with different authoring tools [5], based on the use of serious games, are now needed and are more effective and are increasingly in demand. It has been proven that with them the student's participation in the learning process is more intense and effective.

Virtual and augmented reality systems and immersive systems are proliferating. Large companies (Facebook, Google, Apple, Microsoft) are betting heavily on these technologies. In the near future, everyone will be producing digital content for these devices.

The success of MOOCs [6], invisible learning [7], new theories based on social constructivism [8], connectivism [9], flipped Learning 3.0[7], adaptive ubiquitous learning [10] and intelligent assistants or chatboot[8] are latent in the new digital society. The use of these systems has a favorable impact, both in the decrease of the dropout rate and in the high acquisition of knowledge by students. This is the design-for-all approach.

More and more learners are using e-Learning systems, whether on computer, tablet or even mobile. Personalization through adaptive intelligent systems applications begins to be a necessity in the new way of access to knowledge after the Covid-19 crisis.

If we design new state-of-the-art digital contents and Authoring tools for the production of these contents, which integrate previous technologies and new learning models in a ubiquitous *Transmedia-Learning* (Tm-Learning) platform, we can achieve an online learning ecosystem that is more effective than the current systems.

[7] https://digscholarship.unco.edu/heflc/2017/schedule/2/.

[8] https://www.researchgate.net/publication/290472812_IEEEIBM_Watson_Student_Showcase.

With this in mind, the online learning ecosystem, TELEDU, was developed and a new concept of learning objects was defined: *Transmedia Open Online Content* (TOOCs[9]).

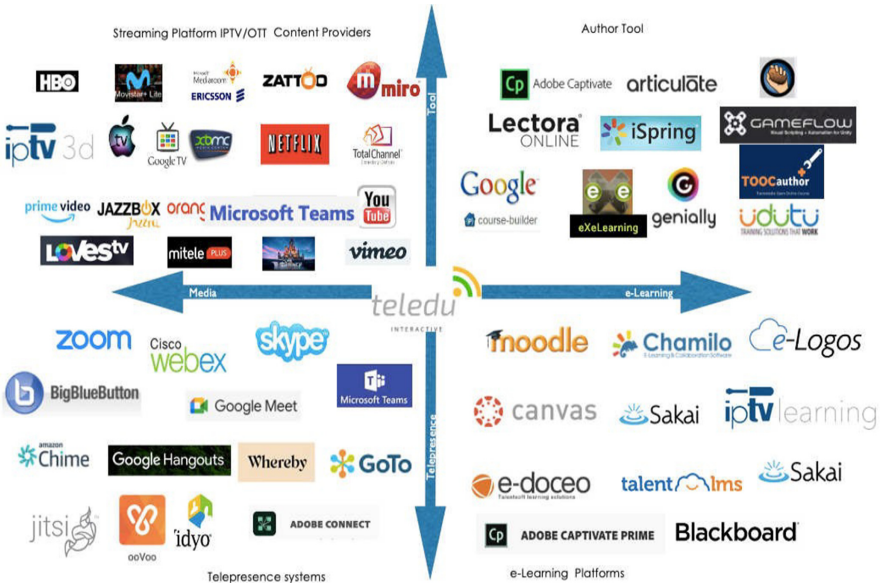

Fig. 2. Main providers of streaming, videoconferencing, Authoring tools and e-Learning platforms. Own source.

The most important key to take into account in a transmedia narrative is user participation through interactivity and gamification [11]. The role of the audience in transmedia storytelling is quite active. We must encourage them to participate and give them their own space to interact and contribute with comments and ideas. The implementation of game mechanics in non-game contexts leads to greater user participation [12].

The growth of *Over-The-Top* (OTT) Internet and mobile video streaming services is a major development in the distribution, transmission and consumption of global media sport [13]. During the Covid-19 pandemic, the use of IPTV/OTT systems [14], streaming video, authoring tools for content creation, and e-Learning platforms, live or *Video on Demand* (VOD), in the different social networks (Youtube Live, Vimeo, Facebook Live, Twitter, Periscope, Instagram), for entertainment, *webinars* and online classes has increased (see Fig. 2). These technologies have favored the exponential growth of iDTV systems, whether on the computer, tablet or even the cell phone.

3 Methodology

This work has been divided into two stages: the development phase of the TELEDU ecosystem and the evaluation phase.

[9] https://www.oepm.es/es/signos_distintivos/resultados.html?denominacion=Contenga&texto=tooc&p=2.

3.1 TELEDU Development

TELEDU is the result of 20 years of research and development by more than 10 university groups from RedAUTI.

Because of the collaboration between the different agents, **a hybrid standard was created**. This standard integrates Ginga[10] (for IPTV services and the *Nipo-Brazilian Digital Terrestrial TV System* (ISDB-T_B)), and the European (*Hybrid Broadcast Broadband TV* (HbbTV)) and the Chinese (*Digital Terrestrial Multimedia Broadcast* (DTMB)) standards, with the SiestaCloud ecosystem, for the development of interactivity applications on *Internet Protocol Television* (IPTV) and *Digital Terrestrial Television* (DTT). All this considering the SIMPLIT usability standards and the accessibility of the *World Wide Web Consortium* (W3C).

The implementation of an authoring tool for the development of interactive DTT/IPTV applications was contemplated, under the concept of existing templates in open access repositories that would be an extension of the Unity framework, for the creation of 2D and 3D content, with easy-to-use extended reality. In this way, prosumers (producers + consumers) do not have to program a single line of code.

A methodology for the production of accessible, adaptive and standardized audiovisual material in the cultural, entertainment, educational and commercial context was also proposed [15].

The TELEDU model is a hybrid IPTV/OTT ecosystem that is composed of three components: technological, methodological and of evaluation:

1. **The technological component** covers the design and implementation of a ubiquitous online learning platform, with a usable and accessible interface for interactive digital television (IPTV Learning) and the development of the Author tool, TOOC Author, for the creation of transmedia learning objects, open online.
2. **The methodological component** comprises the design and development of online learning models based on connectivist theories [9], flipped learning 3.0 and ubiquitous learning [10] in Tm-Learning platforms, using *Connective Massive Open Online Course* (cMOOC) interactives and serious games. In this methodological part, these components were analyzed and evaluated, taking into account the different learning theories and the ideas arising from the networked community.
3. **For the evaluation,** a testing stage has been proposed to guarantee both the quality and the effectiveness of the evaluation system model, the technology, and the contents or learning objects. These tests are of usability, accessibility and effectiveness in the learning levels achieved. For this purpose, several scenarios and models with students in formal training were considered.

3.2 Ecosystem Assessment

In order to test the effectiveness of the didactic models in the levels of learning achieved, the starting point was the definition of ubiquitous training models, in which different elements intervene: permanence, accessibility, immediacy, interactivity and adaptability [16, 17].

[10] http://www.ginga.org.br/es/sobre.

Once the models were defined, one was selected and we proceeded to the instructional design and content development in two subjects: Automatic Regulation, from the 3rd year of the Electrical Engineering Degree, and Integrated Production Systems, from the master's degree in Industrial Engineering, taught at the Superior Polytechnic School of the Universidad de Córdoba.

An evaluation system based on traditional MOOCs was proposed, using the Moodle platform, which served as a reference model to evaluate our proposed learning model, using the IPTV Learning platform and substituting MOOCs for TOOCs. The TELEDU proposal offers an evolution from MOOCs to TOOCs. A TOOC is a content, or transmedia learning object, open online, with a series of properties that identify it. It has to be gamified, interactive, usable, accessible and adaptive, designed for different types of devices and platforms (Smart TV, tablets, Smartphone, PC, VR glasses, e-books, etc.), complying with different standards (Scorm, SIMPLIT, W3C…).

For the evaluation process, the *"Sistema de Información y Atención al Usuario"* (SIAU) methodology was applied to a sample of 200 students in different academic courses.

In the first two months, the subject was taught in the traditional way. In the remaining two months, this methodology was applied with similar theoretical and practical contents.

An evaluation test was given at the end of each period. The results obtained by the students were measured and relationships were established between the results achieved with the proposed model and those achieved using a traditional pre-classroom or online course. The results showed that 95% of the students had learned much more with the TELEDU model and had had fun, although they had also worked harder. The difference in grades was evident. In the first exam, 48% of the students passed, while in the second exam, 95% passed.

To test the effectiveness of the model, usability (SIMPLIT12 Seal), accessibility (W3C13) and effectiveness in the levels of learning achieved were tested, comparing with the results of traditional e-Learning system models, using the methodology for determining attributes and metrics in *Adaptive Educational Hypermedia Systems* (AEHS) based on learning styles [17].

Finally, the usability of the learning environment was assessed through the Jakob Nielsen[11] heuristic evaluation survey among students.

4 Results

4.1 TELEDU and TOOC Author Ecosystem

TELEDU is an ecosystem that integrates the latest technological trends in human-computer interfaces and ubiquitous computing systems, cloud computing, artificial intelligence, blockchain and multimodal systems of interaction by gestures, movement and voice, in addition to *Internet of Things* (IoT).

TELEDU (Fig. 3) is composed of hardware (computer, tablet, smartphone, *STB*) and software (SiestaOS 2020 operating system, the IPTV Learning platform, and the authoring tool TOOC Author). It is compatible with any type of input and output device,

[11] https://revistas.ucp.pt/index.php/gestaoedesenvolvimento/article/view/83/75.

state-of-the-art, including virtual reality glasses and gloves, video game devices, IoT sensors, etc. In addition, it can adapt to the various iDTV standards (ISDB-T, HbbTV, DTMB, etc.).

One of the recommendations of the ITU-T Telecommunication Study Groups indicates that digital content and multimedia applications intended to run on IPTV terminal devices should be platform-independent, so that content creators and providers do not have to develop specific applications for each existing platform and device. It has been taken into account in the development of the authoring tool TOOC Author.

TELEDU has TOOC Author, which is complemented by Genially[12], designed and created by graduates of the Universidad de Córdoba, which is made available to students and teachers, allowing them to easily produce a TOOC.

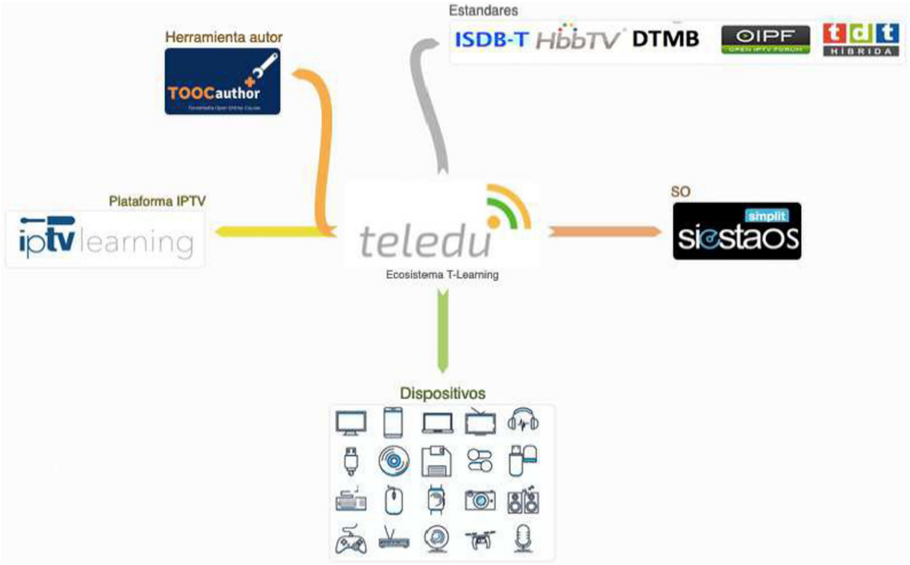

Fig. 3. Main providers of streaming, videoconferencing, authoring tools and e-Learning platforms. Own source.

4.2 Solution in Areas of Limited Bandwith Resources

The TELEDU ecosystem offers access to the IPTV Learning platform without the need for broadband WiFi at home.

Taking into account that, sometimes, families only have a TV with satellite or terrestrial connection, fed by a transmitter center for the educational TV channel, and a cell phone with 3G, a minimum equipment infrastructure has been designed to provide coverage.

[12] https://intef.es/wp-content/uploads/2019/03/Art%C3%ADculo-Genially-3.pdf.

This infrastructure consists of a STB decoder, a keyboard and a mouse (see Fig. 4). The STB is installed with the 2020 evolution of the SIeS-TAOS operating system, based on Ubuntu 2020, the Firefox Browser 83.0, the IPTV Learning platform, and the contents and resources according to the course(s) to be received.

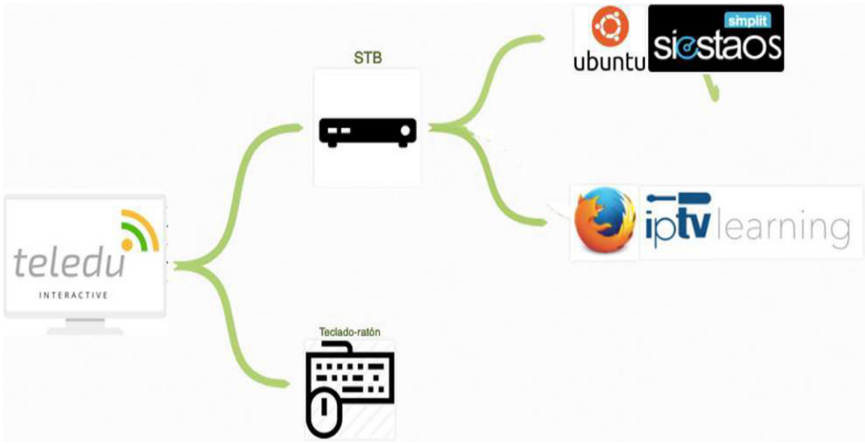

Fig. 4. Minimum hardware and software components of TELEDU. Own source.

4.3 Evaluation Resources Among the Surveyed Students

The most salient aspects that can be concluded from establishing the TELEDU methodology, which correspond to pedagogical interaction, test results, TOOCs quality assessment metrics, and learning styles test are:

1. Learners prefer visual and interactive content, especially videos, simulations, virtual reality, augmented reality and serious games. Interactive multimedia self-study learning objectives, with this type of digital content, are highly valued.
2. Eighty percent of the students only complete the activities and evaluable tasks, those that give them points to pass the course. If these activities are gamified, 98% of students have successfully completed the course.
3. Students learn more when they themselves are the ones who have to actively work on the lesson, search the Internet and provide resources and complementary information on the subject. It is when they become prosumers of information and knowledge (informal learning).
4. Students value positively the teacher who develops quality transmedia content, and negatively the one who just posted his notes and presentations in a *Learning Management System* (LMS). They also value positively the learning methodology based on critical thinking.
5. In fully online education, students' assignments must be very well planned. Follow-up should be continuous without reaching an exhaustive control by the teacher and giving a certain flexibility for the completion of the tasks and activities to be developed.

6. Students should feel that they are being tutored. The teacher must attend daily to questions, doubts or problems in a personal way, and to collective consultations through forums and videotutorials.
7. Students, in addition to the online activities, prefer to have a written reference guide, like a book, on the contents and methodology of the subject (transmedia).
8. Students prefer to use the latest technologies (virtual reality, augmented reality, immersive systems, serious-games, etc.). With regard to hardware, mobile touch-screen tablet systems, ultrabooks, IPTV, virtual and augmented reality glasses, are the most popular devices used to run a course (multi-device).
9. Synchronous systems (telepresence, chat, etc.) are not well accepted by learners if they are imposed on them. They prefer to use them according to their needs and not when the teacher plans it. They prefer to use telepresence and chats with the teacher for personal tutoring or among themselves.
10. Social networks are the incentive. They are used to it in their daily life (connectivism).

5 Conclusions

This paper presents TELEDU, designed as a learning model. It is based on critical thinking, connectivist and ubiquitous learning theories, as well as on adaptive transmedia learning objects based on serial games, which allows teachers and prosumers to create lessons with interactive audiovisual content and educational gamification systems, with feedback and scoring, facilitating the automation of student monitoring and evaluation.

By integrating software components, an iDTV ecosystem has been created, oriented to state-of-the-art e-learning processes. It has a fully usable interface (with SIMPLIT certification) for the iDTV based on the concept desktop.

The concept of transmedia, open, online, interactive, usable, accessible, adaptive and gamified (TOOC) content or learning object has been defined and created. TOOC Author has been designed and developed, integrated with the Gameflow Author tool, based on Unity, implementing these new learning objects in the IPTV Learning platform and achieving interoperability, usability and accessibility, which are key features for an application environment of this type, and agreed technical standards to enable such interoperability.

The module has been developed to integrate and embed in the IPTV Learning platform any application, tool or external Web platform. Any videoconferencing system or Web application, which is normally in use, can be integrated, although we cannot guarantee the usability and consistency of the system.

The effectiveness of the model has been tested through usability, accessibility and effectiveness tests on the learning levels achieved, comparing with the results of traditional e-Learning system models, through the SHAE methodology, based on learning styles.

A Tm-Learning IPTV/OTT for online learning called IPTV Learning has been developed and approved for occupational training in Spain and is in the process of approval in Chile.

Finally, a tool is being designed to convert the graphical user interfaces of external applications to the concept desktop interface, with SIMPLIT seal of usability.

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