An Engineering Educational Application Developed for the Brazilian Digital TV System

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Abstract - Recent studies pointed out that Brazil has a deficiency of about 40,000 engineers. It is well known the continental dimension of this country turning any nationwide educational policy difficult to be implemented satisfactorily. Indeed, in order to be successful it is necessary to create a program able to cover the whole country and with good acceptance of the population. Television is the most popular source of entertainment and information of the Brazilian population being present in approximately 90% of the homes. Nowadays, the Brazilian TV system is moving from analog to digital. That means that will be possible to offer personal interactive services such as home banking, games and most importantly, educational programs. That is the main objective of this work: to investigate and present the necessary elements for developing interactive educational systems for Digital TV (DTV). The paper starts with a study of the technologies involved in the development of such systems, as well as an analysis of the necessary elements for the proper use of DTV educational applications and the importance of this new media in teaching engineering. A basic application is presented in order to validate the involved theory. Furthermore, as a concluding experience, an interactive game developed for teaching computing engineering principles is presented. Finally, the results obtained when the educational application was used in a class of high school teenagers are presented.

Index Terms – Educational Application; Interactive Digital TV; Educational Games

INTRODUCTION

Studies have pointed out that Brazil increased significantly the use of new technologies during the last decade [1]. These technologies became more accessible to a wide part of the population, reducing the differences in social classes and democratizing the use of social relevant technologies such as cellular phones, network systems, automatic systems and other helpful equipments. As a matter of fact this lead to a lack of trained people capable to work in this new industry. This fact shows us how important it is to develop new methods and educational tools to provide a more efficient learning, and to motivate the students to increasingly explore their knowledge in engineering.

In recent years the traditional engineering education approach has presented several deficiencies in Brazil. General education literature as well as technical education literature has shown methods that enable us to learn more effectively than the traditional single-discipline lecturing approach did [1].

Therefore, considering that Brazil has a deficiency of about 40,000 engineers and its continental dimensions, a distance education course seems to be a good choice to increment the national engineering education. Some experience reports have showed that this education approach is well suited for engineering education and Brazil already proved to be one of the pioneers in this field [3].

Actually, the most popular interactive technology used in distance learning until now deals with computers and the Web. However, access to computers is seen as a major problem in poor countries like Brazil [5]. The majority of Brazilian population does not have access to the Internet. The use of internet at schools is also limited because the majority of schools in Brazil have no easy access to internet and because of the lack of competence among teachers [5]. The internet courses have faced problems due to difficulties with downloading audiovisual files [6]. Web-based learning also has the following problems [7]: users get lost in the maze of hyperlinks on the internet; the speed of the Internet connection is limited; the maintenance of a web-based course implies much overhead; the cost of being on line is too high.

On the other hand, the television set is present in more than 90% of the homes, which represents approximately 54 million of families. Today, the Brazilian Television is not digital, has no interactivity and has only a limited amount of programs. Actually, the Digital Television (DTV) System is being implemented in Brazil and we expect to have more information channels and interactivity [8].

Indeed, Brazil’s main objective is somehow different than any other country that has adopted DTV: besides improving the reception quality, amount of programs, among other technological issues, Brazil wants to carry on, through DTV, the digital inclusion of the poor population and also introducing massive T-Learning activities [9].

The correct use of Interactive Digital TV System seems to be a useful way to present to students complex concepts,
enhancing their ability to learn. This is supported by photographs, graphics and animations with audio visual stimulators [10].

The DTV technology provides several new features that can be used for learning purposes. However, there are a small number of related experiences of constructing T-learning systems. As in [11], the research problem was determined as follows: How to construct a T-learning model in which:

1. The T-learning model recognizes the main functions with the help of field studies and helps to construct for the necessary artifacts via DTV;
2. The T-learning model is customized according to different student groups’ requirements;
3. The T-learning model is usable in informal and formal learning.

DTV was considered suitable for interactive and collaborative learning games, even though educational games were lacking. The game world is seen as an easy environment to enter and when people are used to digital TV and games, learning games might be easy to adapt [12].

In order to obtain good results with DTV in Brazil it is necessary the concern about the usability of the educational application, to permit the citizen to use all Digital TV possibilities. Thus, the usability in a T-learning application for the Brazilian people becomes an important step to reach the digital inclusion objective considered by the Brazilian government.

The goal of this paper is to show how to project an engineering educational application developed to a DTV system in Brazil, considering the local resources and limitations [13, 14].

More specifically, the work presents a consistent study of the technologies involved in the development of such systems, as well as an analysis of the necessary elements for the proper use of DTV educational applications and the importance of this new media in teaching engineering. A basic educational interactive game to teach some concepts of computer science is presented in order to validate the involved theory, and the results obtained by the application of the game to a teenager class is presented in the last session.

TECHNOLOGIES TO DEVELOP DIGITAL TV APPLICATIONS

To implement applications designed to the DTV systems it is necessary to know the standards used in the region and how to use important components to create the development, execution and tests platforms. In this work we have opted to use free software that will be presented afterwards.

I. Some concepts about Digital TV Systems

A conventional DTV system is composed by three layers. The first one is called application layer and it is where the applications are implemented such as movies, news, e-mail, e-commerce, interactive games and other applications.

The second layer is the telecommunication service layer and its function is to get the multimedia transmission and the picture format. The main formats are: LDTV (Low Definition Television), which has low definition pictures for television services on mobile devices; SDTV (Standard Digital Television), that may use one of several different formats taking the form of various aspect ratios, depending on the technology used in the country of broadcast; EDTV (Extended Definition Digital Television), that has better picture and sound quality than SDTV, but it doesn't measure up to the HDTV standards; and HDTV (High Definition Digital Television), the best picture resolution, but the most resource consuming to transmit the signals over the air [9].

At least, the third layer is the software platform and it refers to the standard DTV definition, which is the set of technical specifications needed to the DTV operation, used to the development of interactive applications. Basically, a standard is defined by the compression schemes and the audio and video codification.

Digital TV standards adopted worldwide are ATSC (Advanced Television Standard Committee) created by the United States of America which prioritizes high definition on television, the DVB (Digital Video Broadcasting) proposed by the European Commission and focuses on multiple programming, interactivity and new services, and the ISDB (Integrated Digital Broadcast System) developed by Japan where the main characteristic is its proper use of mobile devices as TV receptors [14].

The standard adopted by the Brazilian DTV System (SBTVD) is based on the ISDB including some changes and it is called ISDTV (International System for DTV). The ISDTV brings together the resources of mobility, portability, high definition, data transmission and segmentation, which are the channel subdivisions that allow simultaneous transmission of programs in the same channel.

ISDTV is formed by a set of components related to the application, signal codification, multiplexing and transmission, as in ISDB standard. The reception of data occurs in the application layer, like video, audio and new interactive services. In the signal codification level, the video and audio signals are compressed using the systems MPEG-4 and MPEG-4ACC, respectively.

The main difference between ISDB and ISDTV is the interface that supports the interactivity and new interactive services, known as middleware, which was developed by two brazilian universities, Universidade Federal da Paraíba (UFPB) and Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio), involved in a government initiative to develop a brazilian DTV standard. Created to be open source software, the Brazilian middleware is called GINGA.
II. The Middleware

More specifically, the middleware is an interface between the applications and the operating system. It is also known as API (Application Programming Interface) which is intended to provide a standard for applications without differences on the layer of the operating system and hardware that supports the services of decoding, modulation and transport [15]. An example involving this work is presented in Figure 1.

![Middleware Diagram](image)

**FIGURE 1**
PORTABILITY BASED ON MIDDLEWARE

The main advantage of the middleware usage is the portability that it provides for applications and it can be used in any digital receiver (STB) which offers support to the adopted middleware. There are different standards of middleware for DTV systems, offered by the various organizations of standardization, some of them are: DASE, MHP, ARIB and GINGA [15].

DASE (DTV Application Software Environment), offered by the ATSC standard, is an API which allows the execution of interactive applications and interactive contents in procedural and declarative languages for Java applications, HTML applications and JavaScript.

MHP (Multimedia Home Platform) was proposed by the DVB pattern. It is used in digital receptors to execute applications in procedural language using JAVA.

ARIB (Association of Radio Industries and Business) developed the standard ISDB, which consists of two specifications, ARIB STD-B24 (Data Coding and Transmission Specification for Digital Broadcasting) and ARIB STD-B23 (Application Execution Engine Platform for Digital Broadcasting).

GINGA, developed by the Brazilian universities PUC-Rio and UFPB, is the Digital TV Brazilian System middleware, divided in two platforms according to the paradigms of programming: procedural and declarative. In the first one, called GINGA-J, it is used to support procedural applications in Java language. In the second one, called GINGA-NCL, it is used to support a declarative language called NCL (Nested Context Language) based in hypertext documents.

The platform GINGA-J uses other APIs to the processing of compiled Java classes, which are considered as components, each one to a specific service. To develop applications with GINGA-J it is necessary to use the Java TV, which was developed by Sun Microsystems as an extension of the J2ME environment - Java 2 Platform Micro Edition [16]. As a Java platform extension, the Java TV is an API used to develop the content of DTV. The Java TV applications are called Xlets.

We can say that Xlets is similar to an Applet (used in web) or a Midlet (used in mobile phone). The Xlet has a life cycle that is divided in 4 states: Loaded - created by the application manager; Paused - it does not use the shared resources and needs to release resources; Active - it activates the functionalities and executes them normally; Destroyed - it releases the resources and finishes the execution.

III. Digital TV Emulator

The process of embedding the application consists of transporting the developed software to a DTV or a set-top-box hardware platform [20]. However, for implementation of the educational game used in this work and its validation tests, the use of an emulator is enough. The emulator is installed on the computer, and in practice it is an interface to test interactive television applications on the PC, providing a simulation of a DTV environment.

After a quick search on the existing emulators, we found some open source softwares licensed by the GNU Public License, including the XletView and OpenMhp, both of them used in the development of our application.

The use of these emulators is a trivial task, and requires only some familiarity with the Java language and can be reached at [16]. The main motivation to use emulators is the facility of implementation, compared to the application embedding, and the fast return of the tests and results.

MODELING AND IMPLEMENTING AN EDUCATIONAL GAME TO BRAZILIAN DIGITAL TV SYSTEM

To show the applicability of this proposed work and after analyzing carefully the required resources to create an educational application to DTV, we developed the EdTec game which is an educational game for computer science learning by using the DTV resources, particularly the interactivity, allowing students to test their knowledge and to establish their own learning pace, among other possible benefits from the DTV technology usage. The game was based on basic concepts of computer science and simple questions and answers steps to evaluation, similar to Quiz Game, whose code can be accessed and modified by any user in [17]. Its main focus is to validate the technologies used to the development of Digital TV educational applications, considering the criteria of an educational game presented along this work. Other successful usages of Quiz applications for the Brazilian DTV System may be found at [21, 22]

The EdTec game presents the theoretical contents in technology or other desired courses, as in Computer Science, in our example, and after this, presents interactive questions and answers. In the end it shows the grade obtained by the student. Its objective is to be a
complementary tool in the teaching-learning process, awakening the students’ curiosity, motivation and interest.

The game facilitates learning and allows the student’s capacity of retaining information because the student learns while she/he is playing. The game classification due to its objective is Educational, that is, it will be used for didactic purposes. The development platform was JavaTV with the use of Digital TV technology.

I. Functional Diagrams

The game modeling was designed using the Unified Modeling Language (UML), a graphic notation language which enables one to specify and visualize the desired functionalities.

II. Implementing the Use and Interfaces of EdTec Game

In this stage, EdTec game was implemented based on the described model system considering the user interfaces and data treatment. The code was generated using the JavaTV API, because it attends to the requirements of the Brazilian Digital TV standard, as described in [16] with the graphical libraries AWT and HAVI, and an Xlet View emulator.

Simple elements and screens without great effects provide focus on the main information, preventing the user attention dispersion. We established the concept to fix the option in the center of the screen, which is the zone of higher user perception. The colored buttons functionalities had been disposed in the screen as presented in the remote control.

To test the application it is necessary to open it through the OpenMHP emulator and import the Xlets. A set of three windows appears as shown in Figure 4. The first window has the exit code, the second one has the application interface and the last one represents the remote control.
The user interacts with the game through the remote control that the emulator presents. The EdTec has a simple interface. It contains a menu where the player can start to play, ask for help, visualize his credits or leave the game.

In the beginning of interactive evaluation the players will meet thirty multiple choice objective questions. They will have four alternatives each. After answering one question they will have to answer the next question and on the inferior bar he will be able to see the previous question result, according to Figure 5.

Along the questions the player will score 1 (one) point for each correct answer and in the end of the questions the player will be judged as regular, good, or great depending on their results, they also will have the option to play again, as presented on Figure 6.

RESULTS

To validate the educational game we considered the software ergonomic concepts and the pedagogic research. According to [18] they are important pieces of knowledge to evaluate the quality of the final product or its development. Therefore, it was necessary to include the desirable issues on the educational software such as: the technical issues as well as the pedagogic and ergonomic ones.

The checklist method was used to evaluate the student’s performance on the EdTec game according to [19]. Although being limited it is a fast way of evaluating the student’s performance with low cost. A checklist consists of a list of questions concerning the game characteristics of usage and pedagogy.

The EdTec game was applied to a teenager class in a technician informatic course at the Centro Federal de Educação Tecnológica do Amazonas – CEFET-AM, in order to validate the technical concepts of the Digital TV technology and verify the learning results concerning the objectives of the game.

We invite a class with 20 students from a computer science course, who already have taken classes relating to contents of the game, to participate in the tests. The EdTec provides students to remember the knowledge gained in class and also assess the learning acquired. The students answered the questions of the checklist and the contents of the game, its design and evaluated the game as a motivation for the study the computer science contents.

After students played the game they received a checklist form based on the Educational Software Ergonomic Inspection Technique – ESEIT. It associates criteria to a set of questions in order to orient the evaluator on the difficult task of inspecting the pedagogical and economical qualities of the educational software according to [18]. Using the form data we created a table where we added the ‘yes’, ‘partial’, and ‘no’ answers considering these aspects: legibility, concision, learning evaluation and knowledge comprehension. The data generated the graphics presented in Figure 7.
CONCLUSIONS

We presented in this work an engineering educational application to be used with the Brazilian Digital TV System. We explained the steps and tools to develop the application and presented an educational game to teach basic concepts in computer science as a validation of the presented work.

Comparatively to the existing interactive educational systems, based in workstations or internet, the results of the use of our work by the students shows that the application is easier to use and reaches the majority of the students, due to popularity of TV in Brazil. Another advantage is the flexibility to change the contents and the scope of the educational application.

As a future work, we plan to embed the application in a set-top-box and develop usability tests to improve the effectiveness of the education.

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