Collaborative Distance Teaching of Electronics in Synchronous and Asynchronous Environments Using Free Software

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***Abstract*—**The aim of this work was to diversify the supply of vocational training in electronics by developing a methodology based on synchronous and asynchronous distance teaching with access to a specific software for the realization of Online experiments. Despite the fact that Online courses exist in a great quantity, only a few of them deal with complex technologies and collaborative practical activities.

***Keywords*—**Distance Learning, Learning Environments, Teaching Electronics in Distance

I. INTRODUCTION

TRADITIONAL E-learning, which was characterized by the distribution of instructional packets using internet technologies evolved dramatically in recent years, with recent advances of communication. With very high speed links available at residences, E-learning became much more sophisticated, and computer-supported collaborative learning systems, where students are encouraged to interact and use social software (blogs, chats, etc.), became a reality.

Taking into consideration the characteristics of the traditional presential education, even when Online interactions are as real as the presential ones, simply emulating them will not lead to results which are necessarily better [1].

Thus, even when it aims the same educational objectives of a traditional presential course, an Online course requires special methodology to be developed.

One of the big differences between the presential and the Online approaches is the decentralization of the education, which ceases to be dependent on the teacher to rely on the student.

In this situation, the student ceases to be intellectually subordinated, and begins to exercise an autonomy, which leads him to the self-study and to the discernment that learning certainly depends on his own efforts and personal motivations.

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II. CONTEXTUAL ANALYSIS

A. Transactional Distance

Transactional Distance is the deficit of physical proximity among the participants of educational processes. It is an ever-present psychological and communicative gap between any student and his teacher. [2].

Transactional Distance is composed by three sets of variables: Dialogue, Structure and Autonomy.

Dialogue is developed among teachers and students and is focused on the positive interaction that converges to the improvement of the student's comprehension. The nature of this mean of communication has a direct impact on the quality of the dialogue. The improvement of the quality of the dialogue reduces the Transactional Distance. [2]

Structure expresses the degree of flexibility of the educational objectives, of the teaching strategies and of the assessment methodologies. The development of courses strongly structured predicts all the students' possible necessities in order to provide all supervision, orientation and educational material. The application of highly structured programming increases the Transactional Distance. [2]

Autonomy reflects the degree of control that the student has over the educational processes. An ideal autonomous student is emotionally independent of the teacher. [2]

A fundamental advance to distance learning was the development of information and communication technology – ICT. The interactivity intrinsic to the ICTs enhance the contributions of all those involved reducing the Transactional Distance. [2]

Nevertheless, technology is a tool and in this sense cannot assure the quality of the education in an Online approach and even promote a genuine motivation for learning. [3]

In one extreme side, technological means just enable the transference of information without interaction among the teacher and the students. In the other extreme side it facilitates the construction of knowledge with supervision and dialogue, what is called "being virtually together". [4]

B. Target Public

The alignment of the target public with the goals of the course creates the perception that the education to be received will be useful and the perception that the student will be delegated a responsibility after receiving the instruction, what should meet their personal goals [5]

Considering the approaches to distance learning the target public needs to be fit into the profile of the "successful virtual

student" what distinguishes him from the ones who take part in the presential courses. Otherwise the dropout rate at the beginning of the activities would be unsustainable. [6]

The successful virtual student is interested in computers and has access to technology, does not have restrictions to use resources from the internet and video conferencing; he uses e-mails and chat rooms regularly and would not feel hampered by the restriction on audio and image signs usage during the communication process. In a proactive sense this student would be willing to collaborate for the success of his education. [6]

The target public of this research is from institutions of secondary education consisting primarily of young adults who are in their second semester of a regular vocational course in electronics or of professionally experienced people without academic training who, in a diagnostic assessment, show domain of the pre-requisites necessary to follow up the activities proposed.

C. Electronic Learning Model

An electronic learning model is a set of practices compound by the educational approach, the learning necessities, the characteristics of the target public, the ways of interaction among the people involved, the technique of gathering and producing content, the assessment process and the use of the technological infra-structure. [7]

The electronic learning models can be sorted in Informational, Additional, Essential, Collaborative and Immersive with distinct characteristics that progress in terms of interaction among the ones involved and the load of the infra-structure (maintenance, memory capacity and bandwidth).

In this research the electronic learning model is based on the Essential model, which means an robust infra-structure with constant access to the internet, but the content was made available by the teacher in a learning environment, that resembles the Informational model, which could be accessed asynchronously at any time or on previously established moments because of the synchronous classes. The practical activities followed by the teacher were developed by the students from an electronic emulation software.

The educational model is pedagogical as its content was determined from the foreseen learning necessities but was directed towards the andragogical model as the practical activities allowed the student to modify the itinerary of the practices in search of the expected results.

D. Instructional design Model

Instructional Design – ID is the process of identifying, implementing and evaluating an educational solution from the identified learning necessities. [7]

The fixed ID is characterized by the solid and anticipated planning of the structure of the course, the conception of the flux of activities, the definition of the automation, the existence of interaction, its format and its intensity. The fixed ID is usually used as a solution for mass education that can even dispose the teacher. [7]

The Open ID privileges the educational processes, values the interactions and customizations and does not promote massification. The artifacts created can be modified and improved during the execution of the activities based on the feedbacks from the students.

The Contextualized ID is a combination of both the previous models because privileges the planning but predicts the necessity of adjustments. The extent of the personal relations and its interactions extrapolate the relations among the teacher and the students taking into account the sociopolitical and cultural influences. [7]

In this research, the Open ID was the one that most approximated to the planning and execution of the activities once the interactions were restricted to the students and to the teacher, whose presence was necessary. However, there are typical elements of a Fixed ID because its activities were planned in a structured manner, even predicting changes from the feedbacks during the execution. The content was planned to be accessed from the environment repository but also from the internet.

E. Process of Production

The methodology most diffused to develop new training programs is known as Instructional Systems Design – ISD, which core is the feedback of the creation process. [8]

There are more than one hundred variations of ISD, but most of them is based on the production model ADDIE, which is divided in five stages: Analysis, Design, Development, Implementation and Evaluation, from where the feedback is obtained.

In the Analyses stage it is identified the distance between what is expected to be obtained and the actual state of the process. Then the goals for the approach to the elimination of the identified gaps are established.

The Design is the specification stage in which the instructional strategies are established, the media, software, hardware, the content classification and the way in which the contents will be grouped.

In the Development stage the solution prototype is tested. The identified problems feedback the previous stages for corrections and new tests until the solution is validated.

In the Implementation the course is produced and loaded on the learning environment in order to conduct the performance tests and necessary corrections.

The Evaluation stage feeds back the process continuously and permeates all stages from analysis to the application of the course.

In this research the production of the Pilot Course assembled the ADDIE model and the Open ID Electronic Learning Model resulting in fast and brief in details Design and Development stages. In the application the activities were presented in a balanced way and the obtained results were analyzed in a collaborative way and could be incorporated to the content of the course.

F. Infra-structure

An education strategy would not be viable if the access to

the internet were not constantly available, trustful and of good quality. Communication fails Failure of communication is one of the main reasons of dissatisfaction and frustration of the students, increasing the dropout rate. [9]

The success of an educational in distance approach cannot prescind a strong partnership with the IT area. [9]

The specialists on IT are responsible for the good performance of the infra-structure and, based on the requisites provided by the pedagogic team, project and maintain the computing environment that contains hardware and software to the execution of the educational activities.

There are five types of learning software which can be employed alone or combined: Programming Language, Authoring Packages, Learning Management Systems – LMS, Content Management Systems – CMS e Learning Content Management Systems - LCMS. [10]

In this research, the employment of Programming Languages was abandoned because the profile of the professionals of the Educational Institutions is incompatible with the profile of a software programmer. The Authoring Packages were abandoned because of the difficulties in establishing an intense and diverse interaction among the public of an Online approach.

All the documentation produced in this research was easily cataloged, stored and can be accessed without the use of a CMS, what also, for simplification, eliminated the need for a LCMS.

Then, for this research, a LMS was selected to compose the necessary infra-structure which mission was to warrant the management of the activities flow, the management of the contents and the asynchronous interaction.

For this research there were expected synchronous activities intermediated by video-conferences, white board, computer screen sharing and documents. That is why a tool which offers the functionalities of synchronous activities was incorporated to the infra-structure.

To the execution of the experimental activities it was employed the electronic emulation software SPICE 5, downloaded by the students in their own machines. The teacher accessed the results obtained by the students in real time.

The architecture designed and implemented for this research covered three premises: Open Source Software, low demand of internet bandwidth and low demand of hardware and software in the end. An educational institution could reply the architecture proposed with relative facility and low cost since it had the specific knowledge for the installation and configuration of the servers and the software (Fig. 1).

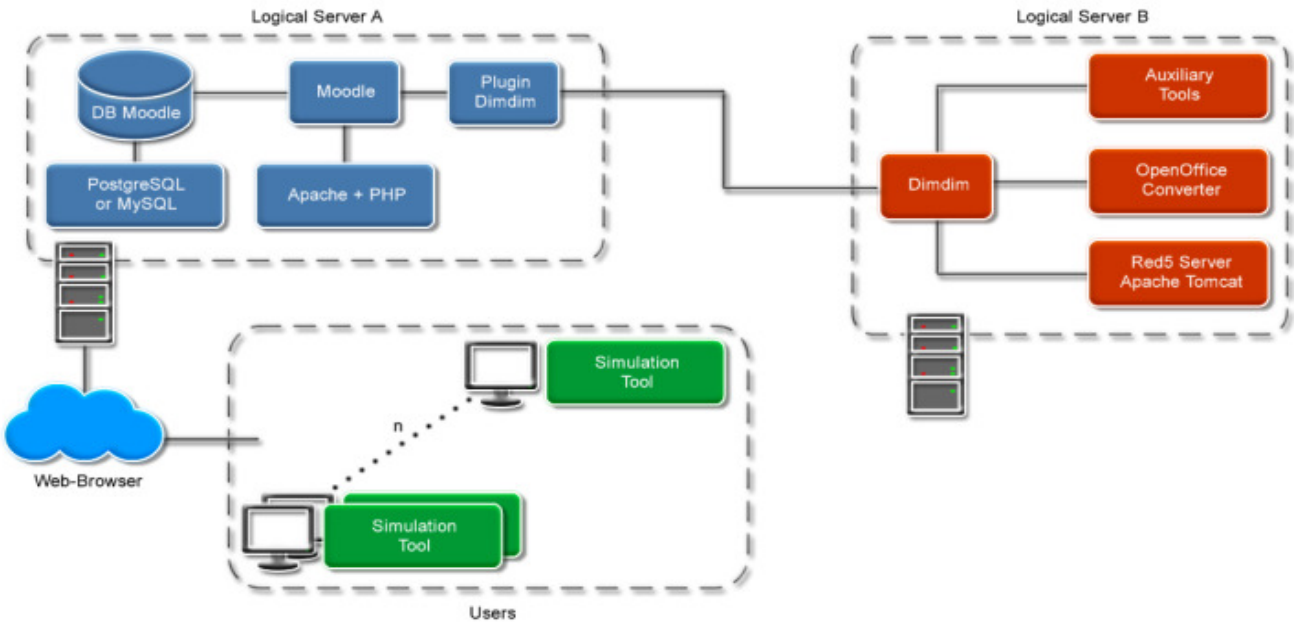

FIG. 1 INFRA-STRUCTURE

G.Learning Environment

To the development of this research it was carried a selection of tools based on the mandatory pre-requisites and the necessary functionalities for the LMS as well as the videoconference tool.

The mandatory pre-requisites considered were: Open Source Software, Onsite Server and Free Support. An unpaid, functional, reliable and of easy maintenance learning environment was sought.

The requisites and functionalities, in a complementary way, achieved by the Moodle and Dimdim tools are presented in Table I.

TABLE I
MOODLE AND DIMDIM INTEGRATION

Functionalities	Moodle	Dimdim	Integration
Audio-conferencing	No	Yes	ok
Exam	Yes	No	ok
Private chat	Yes	Yes	ok
Public chat	Yes	Yes	ok
Computer screen sharing	No	Yes	ok
Document sharing	No	Yes	ok
Instant feedback	Yes	Yes	ok
Forum	Yes	No	ok
Requirements for student	Web-browser	Web-browser	ok
Integration with CMS	Yes	Yes	ok
Open source	Yes	Yes	ok
Student profile	Yes	No	ok
Portability	Yes	Yes	ok
Whiteboard	No	Yes	ok
Notice board	Yes	No	ok
Attendance report	Yes	No	ok
Reports	Yes	No	ok
Repository	Yes	No	ok
Onsite server	Yes	Yes	ok
Free support	Web community	Web community	ok
Guide	Yes	Yes	ok
Free version	Yes	Yes	ok
Video-conferencing	No	Yes	ok

H. Roles and Responsibilities

A distance learning approach is carried by a multidisciplinary team of professional with different competences. The professional competences can be grouped in teams that relate in a synergistic and collaborative way: Management Team, Content Team, Pedagogic Team, ID Team, Art Team, Teachers Team, Pedagogic Supervision Team, Technical Support Team and Technology Team. [11]

In this research the teams were represented by a group of professionals with diverse specialties. The role of the teacher was performed by a professional in the field of the integrated circuit design.

I. Assessment Process

There are three modes of assessment widely known and applied in different moments. [12]

The Diagnostic Assessment applied before the beginning of the activities raises the current situation of the students. The Formative Assessment is continued with the aim of supervise the acquisition and the construction of knowledge and adjust the divergences with the activities under way. The Summative Assessment is applied to verify the achievements at the end of the course.

In this research the Formative Assessment values the work done by the student during the course and corresponds to half of their maximum grade.

The Summative Assessment corresponds to half of their maximum grade and takes place at the end of the course in synchronous and asynchronous modes, corresponding to 20% and 30% respectively.

III. PILOT COURSE PRODUCTION

A. Analysis

The planning of the Pilot Course could be used by educational institutions how have interest in training people in the electronic subject taking the advantages and overcoming the difficulties of distance learning.

The infra-structure was seized to support simultaneously a group of 25 students, a teacher and a monitor.

B. Design

The subject chosen for the Pilot Course was Practice of Operational Amplifiers serving as a prototype for the assessment of the methodology developed. This subject is halfway from a vocational training. In the practical portion of the course were studied typical analog transistor circuits simulated in SPICE 5.

C. Pilot Course Content

Installation and operation of SPICE 5; Models of Components; Syntax for description of circuits – netlist; Electronic Simulation of analogical circuits; Basic Principles of Operational Amplifiers; Configuration and simulation of Inverter Amplifier; Configuration and simulation of Non-Inverter Amplifier; Configuration and simulation of Summing Amplifier; Configuration and simulation of Subtracter amplifier circuit; Discussion of the results.

D. Development

Three basic premises were considered for the development of the pilot course. The first one determines that the content has to be available from the teacher in a learning environment

that can be accessed by the student at any time.

The second premise takes into consideration that the practical activities supervise by the teacher are executed from an electronic simulation software downloaded by the student itself correctly oriented to do so. The third premise is the warranty of constant access to the internet.

From this set of premises and from the content of the course began the process of modularization of the Pilot Course. Modularize means to divide the content of the course into modules. In practice it is constructed the dynamics of the course or the mode how the interactions among the participants will occur, and so defining the synchronous and asynchronous moments that inserted in classes will be distributed in time.

E. Implementation

To infer identity to the Pilot Course it was created a visual pattern used in the generated materials and in the asynchronous learning environment.

The generation of the content was done in accordance to the dynamics proposed in the modularization. All the files available to the students in the asynchronous learning environment are in PDF format. The students may upload files in DOC format. The files generated from the simulation on SPICE 5 have a specific format sch (schematic diagram) and anl (analysis). In some situations there were inserted internet links as proposed on the modularization.

F. Pilot Course Application

The simulation of the Pilot Course was performed to expose the functionalities of the learning environment proposed, employing the many possibilities of interaction. The Modularization Document was the guide that drove the classes and reflected the methodology tested in this research.

Every student received an Welcome e-mail with the Course Dynamics attached. In this e-mail the student also received the login and the password to connect to the asynchronous environment (Fig. 2).

During the simulation the interaction among the teacher and the students occurred through video, audio, public chat and computer screen sharing for practical demonstrations. The teacher was in charge of opening the microphones for the students and for the monitor as well as the screen sharing resources.

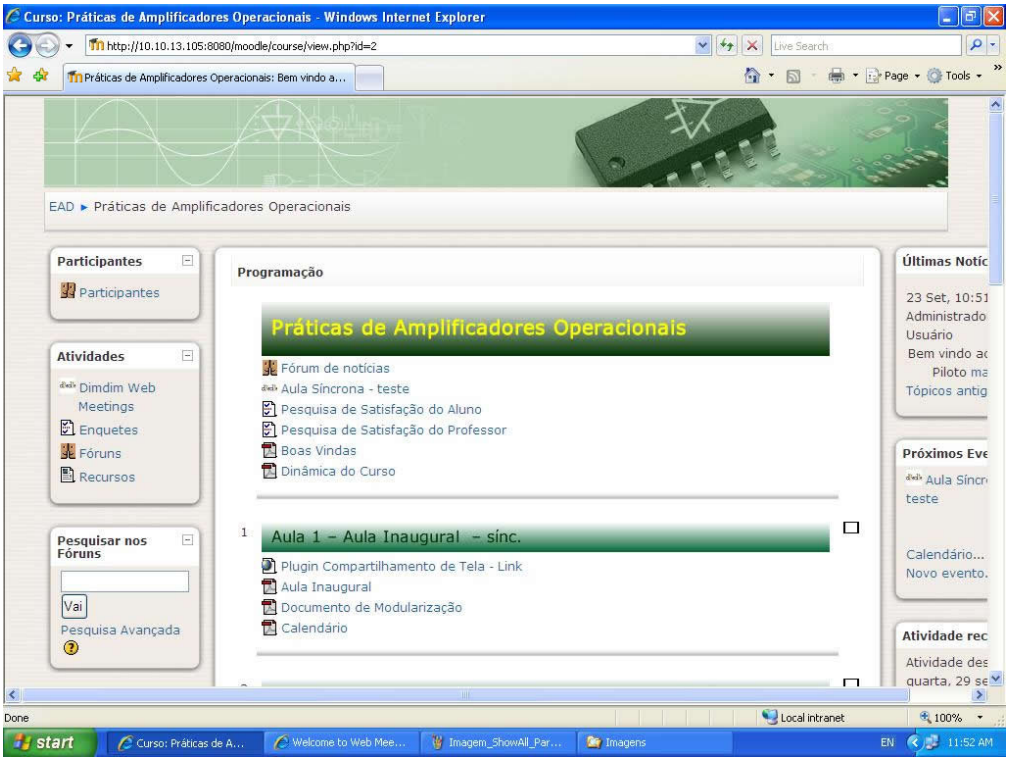

FIG. 2 ASYNCHRONOUS ENVIRONMENT

The interaction between the teacher and the monitor occurred through private chat and the interaction among the monitor and the students occurred through private and also public chat.

When the teacher was presenting her class and was listening to questions and feedbacks from the students through public chat, the monitor was following the public chat attentively and answering questions from the students in the private chat.

This chat dynamics kept the pace of the class preventing the unwanted “moments of silence” to happen. A single break of the teacher to read the public chat could cause incomprehension in the students, who without information, would take it as failure in the internet connection.

It was observed that the teacher could easily conduct the whole class without having to change her focus to answer doubts posted on the public chat, which is under the responsibility of the monitor. In the asynchronous

environment, the students could post on the forum their comments about the class.

The students were oriented by the monitor to open on their machines the tool for electronic simulation SPICE 5, which was previously installed. The teacher gave a brief explanation about the objectives of the class and about the circuit to be studied.

The teacher, turning one of the students in presenter, asked him to carry the edition of the circuit. The student created schematic of the circuit with the installed tool on his own machine. As he was working on the circuit, the teacher and the students could follow and give opinions (Fig. 3).

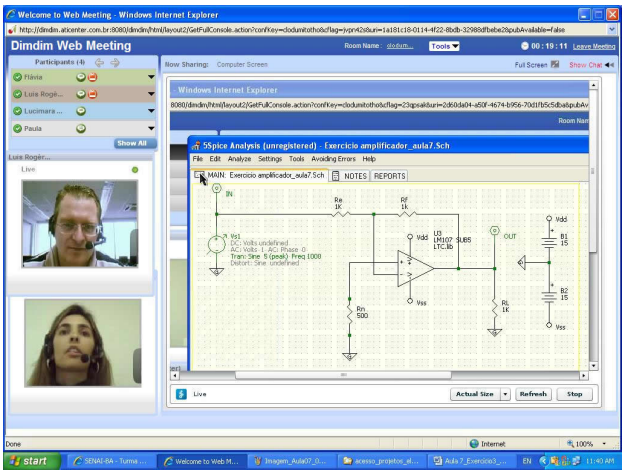

FIG. 3 STUDENT ASSEMBLING A CIRCUIT

After finishing the circuit the student generated a simulation and explained the result to all the participants who in their turn could comment and interact among themselves (Fig. 4).

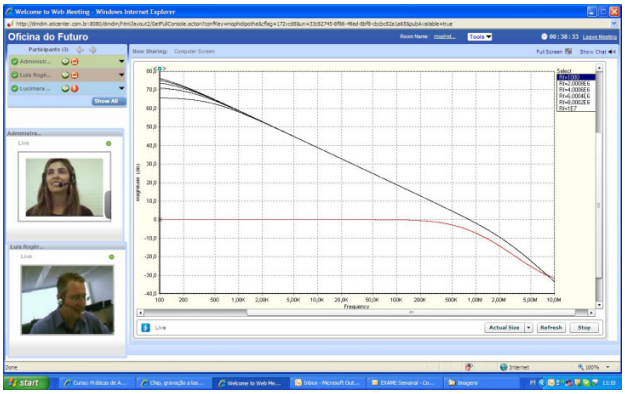

FIG. 4 STUDENT PRESENTING THE RESULT OF THE SIMULATION TO CLASSMATES

IV. CONCLUSION

In this research it was observed that it is possible to offer distance training with interaction and collaboration in subjects in electronics with complex practical activities without restraining the educational process.

It was evident that the success of this approach depends on the right identification of the target public and on a production process that takes into account the inner characteristics of Online interactions.

It was also clear that the high level of dependency on a reliable infra-structure for the success of the distance learning especially in synchronous interactions.

There is a open field for research and development of Online approaches, synchronous or asynchronous, for vocational training, aiming to produce models that efficiently meet the big market demands, whit fair number of trained people and with low costs and widely widespread.

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